Serious Game Development Model Based on the Game-Based Learning Foundation

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Abstract. Serious games or applied games are digital games applied in serious fields such as education, advertising, health, business, and the military. Currently, serious game development is mostly based on the Game Development Life Cycle (GDLC) approach. A serious game is a game product with unique characteristics that require a particular approach to its development. This paper proposes a serious game development model adapted from the Game-Based Learning Foundation. This paper's main contribution is to enhance knowledge in the game development field and game-related application research. The proposed model was validated using the relativism approach and it was used to develop several game prototypes for universities, national companies, and the military.

Keywords: *applied games; game development life cycle; Game Based Learning Foundation; serious games.*

1 Introduction

The most common definition of serious games (SG) is that they are digital games that have a primary purpose other than pure entertainment [1,2]. This definition causes the scope of SG to be too broad, simple and biased [3,4]. SG should be defined as a digital game applied in serious fields such as education, advertising, health, business, or the military [5]. The main function of SG is to help players learning, training and improving real-world skills.

The use of digital media directly separates SG from non-digital game products such as traditional games or board games. But the bias in the SG definition sometimes causes SG to be referred to with inaccurate terms such as game-based learning (GBL) or gamification products [6,7]. GBL and gamification do not refer

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to games but to a method. Thus, it is not correct to treat gamification, GBL and SG as the same subject matter.

A common definition of GBL is the use of play and games in an educational context [8]. GBL can be applied using both traditional games and digital games [9,10]. Meanwhile, the term gamification was originally defined as designing a game-like user interface for electronic equipment [11,12]. The definition of gamification then changed to the use of game elements in non-game contexts [13]. Ludo Science's research on more than 1200 game titles that were categorized as SG found that 90% of them did not help players training or improving skills as their primary goal. Most of them were only message broadcasters [14]. More than 30% was applied in the education sector, which made the terms 'educational games' and 'edutainment products' very popular. The definition of SG and what elements they should contain is still a matter of debate among academics and practitioners [15,16]. Most agree that the true mark of SG excellence lies their application in the field of education and increasing player retention for continuous learning [17].

In this study, the definition of SG is limited to digital games that are applied in serious fields and have an assessment mechanism for its players to improve their skills [18-20]. A mapping of the SG position that is the main focus of this study is shown in Figure 1.

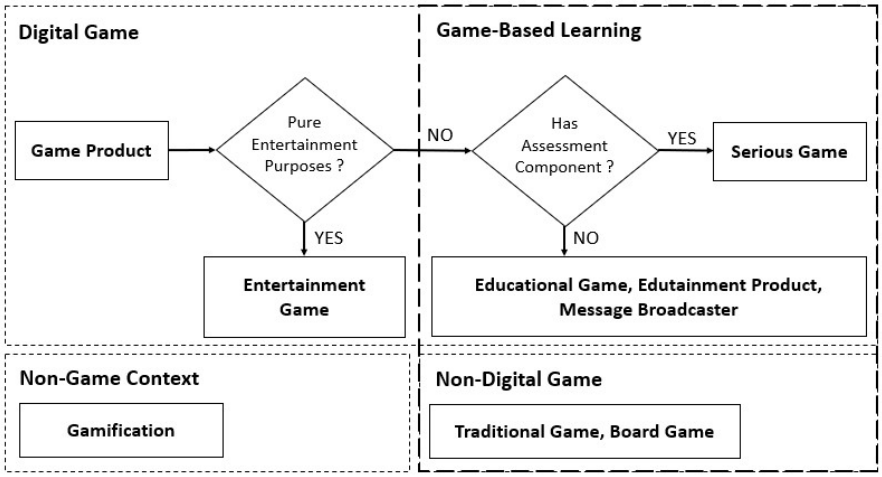


Figure 1 Digital and non-digital game classification.

In general, there are three primary entities, namely digital games, non-digital games, and non-game context. Within the digital games entity there is a

conditional flow that determines the type of game according to its purpose. If the digital game only fulfills the purpose of entertainment, the game is called an entertainment game. If a digital game has features outside of entertainment but does not have an assessment component, it can be called an educational game, a message broadcaster, or another marketing buzzword. If the game has an element of assessment, then it can be called a SG.

Figure 1 shows that as a method, GBL is extensive and can be applied using digital games and non-digital games like traditional games or board games. However, GBL's scope in the following discussion is limited to digital game products.

Most SG are still developed using the Game Development Life Cycle (GDLC) approach [21,22]. Several GDLC models have been proposed for the development of entertainment games [23,24]. Still, this development model is too general to be used as a guide for building SG products that have unique characteristics.

Several studies have tried to create an SG development model adapted from various methods [25,26]. However, these models do not reflect the apparent differences between SGs and regular educational games [27,28]. Therefore, this research aimed to develop a new SG development model by adapting the GBL Foundation to ensure that each stage of development can produce the expected SG characteristics.

2 Development Model Analysis

2.1 Game Development Life Cycles

Game Development Life Cycle (GDLC) is a game development approach derived from Software Development Life Cycle (SDLC). Many studies related to GDLC modeling have been conducted [29,30]. Each GDLC has its strengths and weaknesses. Overall, the main phases of GDLC can be grouped into four stages, namely pre-production, production, testing, and post-production [31].

When viewed from its production activities, GDLC patterns can be classified into two major groups: linear GDLC and iterative GDLC. Linear GDLC adopts the waterfall method, which requires clear product requirements at the beginning of the development process. Meanwhile, iterative GDLC adopts a rapid prototyping method that focuses on development speed and allows changes in requirements during development. Table 1 describes the general patterns of some popular GDLC versions.

Table 1 Game development life cycle patterns.

GDLC Version		Type	Pre-Production	Production	Testing	Post-Production
Entertainment Game	Heather Chandler	Iterative	Pre-Production	Production	Testing	Post-Production
	Doopler Interactive	Iterative	Design	Develop/Re-Develop	Evaluate, Test, Review Release	Release
	Blitz Game Studio	Iterative	Pitching, Pre-Production	Main Production	Alpha Testing, Beta Testing	Master
	Arnold Hendrick	Linear	Prototype, Pre-Production	Production	Beta Testing	Live
	Rido Ramadan	Iterative	Initiation, Pre-Production	Production	Testing, Beta	Release
Serious Game	Eelco Braad	Iterative	Analyze, Design	Develop	Implement	Evaluate
	Elaachak Lotfi	Iterative	Need Analysis, Design	Prototype & Development	Validation	Evaluation
	Arturo Barajas	Linear	Requirement	Design, Development	Testing	Postmortem
	Andre Barbosa	Iterative	Requirement	Design, Learning Mechanism	Testing	Release

2.2 Game-Based Learning Foundation

The GBL Foundation is an integrated design framework for game-based and playful learning, which consists of four main pillars, namely affective, behavioral, cognitive, and social/cultural engagement [32]. Figure 2 shows the integration of game element design with the four main pillars of the GBL Foundation to create high engagement in game-based learning.

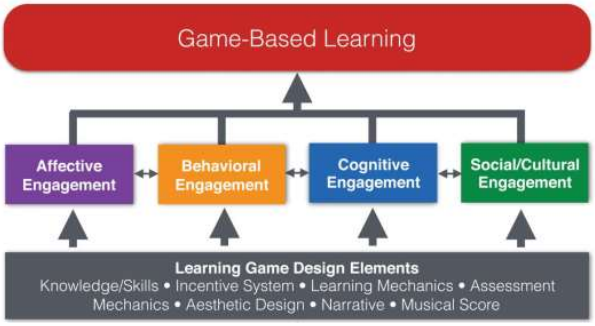


Figure 2 Game-based learning foundation.

The affective point of view relates to the emotions of the player. In this case, the resulting game product must be able to impact players emotionally and change their behavior while providing a multimedia learning experience [33]. Meanwhile, the behavioral or motivational aspect requires that the game should increase the players' curiosity and make them survive to finish the game [34]. Special elements in the game are needed to achieve this, such as an incentive system, good visuals, and challenging game mechanics.

From a cognitive point of view, the games developed must be able to represent educational content with a different look-and-feel [35]. An adaptive form of learning mechanics can increase player attractiveness and give them a different and meaningful learning experience.

Games that have a social aspect can create an atmosphere of cooperation, collaboration and even competition in learning [36]. This can be a learning supplement related to social interactions in addition to the main learning content. The relatedness of a cultural linkage aspect can also make players feel familiar with the game environment that is presented.

3 The Proposed Model

The proposed SG model adopts four main phases in the majority of the GDLC and uses a combination of development patterns for entertainment games and serious games. The GDLC iterative activity approach was chosen because this pattern is more adaptive to changing requirements compared to linear GDLC.

The model also maps the four main pillars of the GBL Foundation as an indicator of the suitability of the SG characteristic for each of its development activities. The proposed SG development model consists of three main layers, namely the phase, activity, and foundation layers.

The first layer consists of a sequence of stages that adopt a popular general GDLC pattern, namely analysis, production, testing, and release. The second layer is a breakdown of the phase layer and adds development activities specific to the serious game characteristic. Activities in this layer consist of education content ideation, tech and art development, learning mechanic, assessment mechanic, prototype, testing and evaluation, and final version.

The last layer was adapted from the GBL Foundation, consisting of four main pillars: affective, behavioral, cognitive, and social/culture engagement. The form of the proposed SG development model is described in Figure 3.

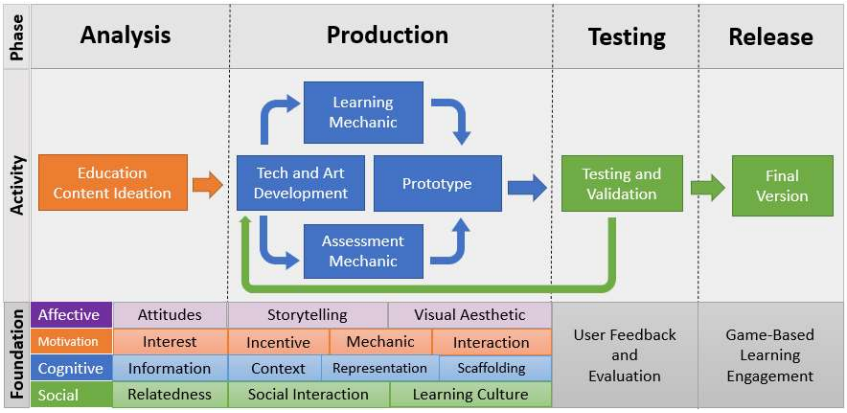


Figure 3 Serious game development model.

3.1 Analysis

The analysis phase aims to determine the important points in educational content that will be implemented in the SG. There are several things that must be considered in this process:

1. The educational content must be able to increase the player's interest in learning it. The game visualization must be designed according to the fundamental art design and UI/UX composition [18].
2. The educational content must be able to guide the player's attitude and emotions in a better direction. The game's challenge should not be too easy, which could cause the player to get bored, and it should not be too difficult, which could cause the player to get frustrated [16].
3. The educational content must be presented in a digital form that can balance multimedia aspects such as text, images, sound, animation, and gaming 'fun-factor' elements [33].
4. The educational content must be adjusted to the target player so that it can provide a connection between the environment in the game and the target player's characteristics.

3.2 Production

The production phase aims to translate the results of the analysis of the educational content into various game elements. This phase consists of four main activities, namely tech and art development, learning mechanic, assessment mechanic, and prototype.

3.2.1 Tech and Art Development

This activity is a core activity that designs and implements educational content in the form of visuals and programming logic. The aim is to build game mechanics and visuals while paying attention to the target player's psychological, motivational, and cognitive aspects.

The use of 2D or 3D visualization in the game strongly depends on the form of the educational content, the target player, and the target platform [35]. For educational content that requires a room simulation in the real world it is highly recommended to use a 3D perspective. For educational content based on writing, numbers, or graphics such as mathematics and physics it is highly recommended to use a 2D perspective. The use of multiple perspectives can be used to increase player interest. For example, a learning mechanic that contains learning material presented in 3D with an assessment mechanic presented in 2D, or vice versa.

One of the main keys in this activity is the implementation of an incentive system. There are many forms of implementing an incentive system in games, such as scores, stars, medals, or achievements. In essence, the incentive system provides a 'reward' when the player is successful in completing a challenge. Furthermore, the games incentive system can also be used as a new learning culture for instructors [19]. In this case, the instructor can monitor the progress of the player in the game, knowing the achievements of each player, including what materials the player has completed or missed so that the collected player progress data can be used to give insight in determining the direction of the next challenge.

3.2.2 Learning Mechanic

This activity aims to present information in the educational content in a more attractive form. The combination of storytelling, visual aesthetic, and user interaction design can make providing educational content easier and less boring [25].

This mechanic's general form is in-game cut scenes, pop-up dialogues against an object, or branching storytelling visual novel mechanics. Giving players the freedom to determine what information they want or do not want to receive can be one way to increase player interest as well as monitor player interest in the material.

3.2.3 Assessment Mechanic

This activity aims to provide a game assessment mechanic, which is a main characteristic of SG. In general, the form of this mechanic is a quiz consisting of

questions and answers [18]. However, the form in which the quiz is presented can be modified by using various game mechanics or in-game entertainment.

There are several examples of game mechanics that can be used to achieve this. One of them is a 3D puzzle mechanism commonly used in AAA games such as Prince of Persia, Tomb Raider, or the Final Fantasy series.

In simple terms, quizzes can be translated into game objects that will react to the player based on certain interactions. As a result, the player has to solve the puzzle as a form of 'giving an answer'. This mechanism is much more interesting than just choosing one of the answer buttons that are available in regular quiz games.

In addition, this form of assessment mechanic is expected to apply the scaffolding concept by changing the difficulty level gradually to provide challenges to players. If the player fails to complete a challenge, the SG must be able to provide the player the opportunity to complete it because one of the goals of SGs is to increase player retention in learning [17].

3.2.4 Prototype

The final result in the production phase is a game prototype that players can test. Many game engines, such as Unreal, Unity, Godot, or Construct2, are equipped with standard game development features. This prototype development process can be done from scratch or by using a game mechanic framework to speed up the development process [37].

3.3 Testing and Evaluation

There are two essential activities in this phase, namely testing the game mechanics and evaluating the educational content. Testing is carried out in stages by various stakeholders ranging from internal game developers, independent external parties, and potential players or those representing them.

1. Game Mechanic Testing

This activity serves to test the functionality elements in the game. Some of the main points tested include the number of levels that can be played, the response of game objects to user input, recording scores, validating gameplay, and checking for possible bugs in the game.

2. Educational Content Validation

This activity serves to ensure that the educational content in the game is displayed as needed. The representation of educational content information in the form of storytelling, game environments, characters, and animations does not reduce the weight of the educational content that must be delivered.

3.4 Release

The last activity is to release games to target markets such as schools, universities or offices. This activity's main target is to create an SG that is a digital educational tool capable of becoming a media in a new learning culture and a medium to increase interest in game-based learning.

4 Results

We used a relativist approach to validating the SG development model. This approach differs from the logical empiricist validation approach, which is strict, algorithmic and assumes that new knowledge must be in the form of true and false statements. In the relativist validation approach, the validation process is a gradual process of building confidence in the new knowledge's usefulness to a purpose [38-40]. This approach is relevant for open problems where new knowledge is associated with heuristics and non-precise designs.

The proposed SG development model was designed with clear objectives and has added value in terms of knowledge related to game development and game-related research. This model passed the engineering process and was developed respectfully towards the previous research literature. Considering the previous researchers' contributions, the combination of knowledge, the engineering cycle and the modeling objectives we argue that the SG development model is theoretically valid.

In addition, we also conducted empirical tests on the output result from the proposed SG development model. We created prototypes of several types of games for various stakeholders over the past two years. All games were created using the same game engine but with different visuals and game mechanics. Details of the games that were made are described in Table 2.

Measurement of user satisfaction was tested using a user experience questionnaire (UEQ), which consisted of a 26-item questionnaire [38-39]. We surveyed various stakeholders at different times. Details of the respondent sample are given in Table 3.

UEQ maps all question points into six classes: attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty. UEQ does not produce an overall score for the user experience but allows the researcher to interpret each classification item's average score according to the survey needs. Details about the survey results can be seen in Table 4.

Table 2 Serious game development prototype result.

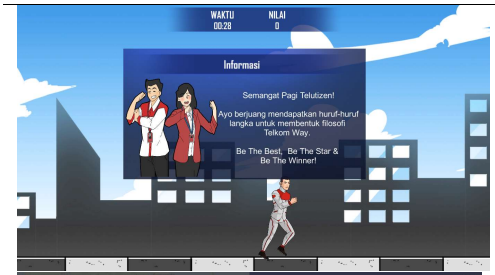
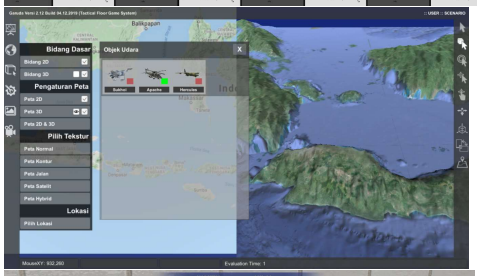
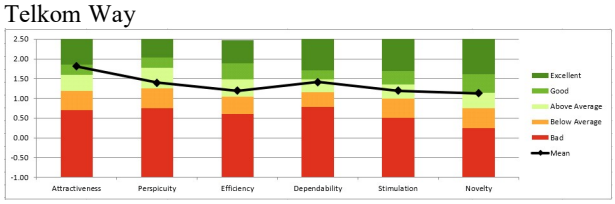
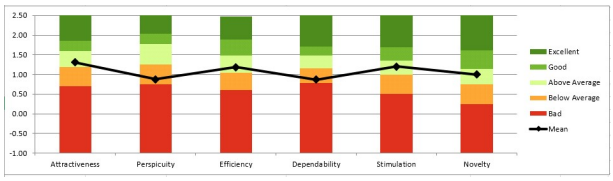
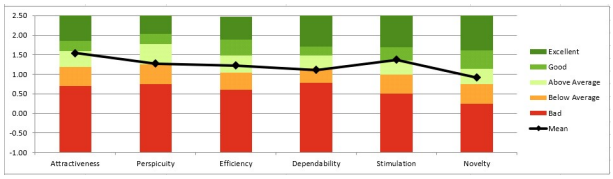
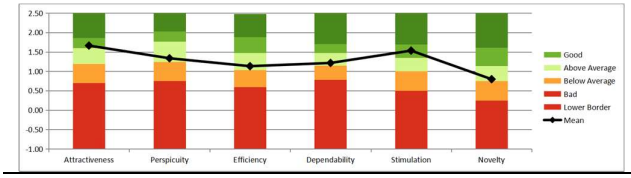
Screenshot	Description
	Title: Telkom Way This game was designed to socialize the company's core values to all employees. There are three main levels, each of which has a different mechanic. Each employee must log in first so that the progress of the game can be recorded.
	Title: Garuda Tactical Floor Game (TFG) This game was designed as a tactical display tool in the study of operational planning in 2D and 3D. The assessment is carried out manually by the lecturer in the form of a TFG simulation.
	Title: Kitchen Labs This game was designed to be a learning aid for hospitality study programs. Even though it was designed with realistic 3D visuals, the main purpose of this game is actually to provide a habit of cooking SOP's in the kitchen.
	Title: Chemical Labs This game was designed to be a chemistry learning aid for junior high school children. It has fifteen levels with a variety of interactions and game mechanics.

Table 3 Respondents overview.

Years	Prototype	Male	Female	Total
2019	Telkom Way	52	17	69
2019	Garuda TFG	16	4	20
2020	Kitchen Labs	21	11	32
2020	Chemical Labs	27	10	38

Table 4 UEQ survey result overview.

UEQ Chart	UEQ Scales
Telkom Way 	UEQ Scales (Mean and Variance) Attractiveness 1.809 0.94 Perspicuity 1.393 0.22 Efficiency 1.191 0.92 Dependability 1.415 0.59 Stimulation 1.191 1.34 Novelty 1.129 0.91
Garuda Tactical Floor Game 	UEQ Scales (Mean and Variance) Attractiveness 1.303 0.73 Perspicuity 0.875 0.41 Efficiency 1.182 0.55 Dependability 0.864 0.64 Stimulation 1.197 0.96 Novelty 1.000 0.79
Kitchen Labs 	UEQ Scales (Mean and Variance) Attractiveness 1.542 1.13 Perspicuity 1.271 0.21 Efficiency 1.227 1.51 Dependability 1.112 1.14 Stimulation 1.367 1.40 Novelty 0.914 0.78
Chemical Labs 	UEQ Scales (Mean and Variance) Attractiveness 1.632 1.07 Perspicuity 1.316 0.22 Efficiency 1.112 0.86 Dependability 1.283 0.82 Stimulation 1.493 1.15 Novelty 0.822 1.01

The UEQ survey results show that the SG products developed based on the SG development model had an average positive value, especially for the attractiveness and stimulation aspects. These aspects are related to a GBL Foundation layer in the SG development model, namely the affective and motivation layer. These aspects result from the implementation of game elements such as the incentive system, game mechanics, and visual aesthetics.

Meanwhile, the perspicuity and dependability aspects are related to the cognitive layer. These aspects result from how the game shows the necessary information to the player. They are also associated with the efficiency aspect related to the social/cultural layer. The efficiency aspect can be seen as a form of user interaction and learning culture change using games.

According to all surveys, the novelty aspect was above average. This point can still be increased because the mechanics used in the game are replicas of general mechanics in entertainment games. In this case, further research is needed to increase the novelty aspect of each SG produced.

5 Conclusion

The proposed SG development model was theoretically validated and empirically proven to be able to be used to create various SG types in multiple fields and agencies. The resulting SG present interesting learning mechanics and assessment in interactive ways that are more interesting than regular quizzes. In general, the SG also succeeded in implementing the GBL Foundation's four pillars, namely affective, behavior, cognitive, and social/cultural engagement. However, further research is needed regarding the development of learning and assessment mechanics in this model to improve the aspect of novelty in each SG produced.

References

[1] Djaouti, D., Alvarez, J., Jessel, J-P. & Rampnoux, O., *Origins of Serious Games*, M. Ma, A. Oikonomou, & L.C. Jain (eds.), *Serious Games and Edutainment Applications*, pp. 25-43. London, UK: Springer London, 2011.

[2] Laamarti, F., Eid, M. & El Saddik, A., *An Overview of Serious Games*, International Journal of Computer Games Technology, **2014**(3), 358152, May 2014.

[3] Crookall, D., *Serious Games, Debriefing, and Simulation/Gaming as a Discipline*, Simulation & Gaming, **41**(6), pp. 898-920, Jan 2011.

[4] Sun, H., Ricciardi, F. & De Paolis, L.T., *A Comprehensive Review of Serious Games in Health Professions*, International Journal of Computer Games Technology, 787968, Feb. 2014.

[5] Djaouti, D., Alvarez, J. & Jessel, J-P., *Classifying Serious Games: The G/P/S Model*, in P. Felicia (Ed.), *Handbook of Research on Improving Learning and Motivation through Educational Games*, pp. 118-136, Apr. 2011.

[6] Loh, C.S., Sheng, Y. & Ifenthaler, D., *Serious Games Analytics: Theoretical Framework*, in Loh C., Sheng Y., Ifenthaler D. (eds.), *Serious Games Analytics*, Advances in Game-Based Learning, Switzerland: Springer International Publishing, pp. 3-29, Jun 2015.

[7] Husniah, L., Pratama, B. & Wibowo, H., *Gamification and GDLC (Game Development Life Cycle) Application for Designing the Sumbawa Folklore Game 'The Legend of Tanjung Menangis (Crying Cape)*, Kinetik: Game Technology, Information System, Computer Network, Computing, Electronics, and Control, **3**(4), pp. 351-358, Nov 2018.

[8] Hellerstedt, A. & Mozelius, P., *Game-based Learning – A Long History*, Irish Conference on Game-based Learning, Jun 2019.

[9] Tang, S., Hanneghan, M. & El Rhalibi, A., *Introduction to Games-Based Learning*, in T. Connolly, M. Stansfield & L. Boyle (eds.), *Games-Based Learning Advancements for Multi-Sensory Human Computer Interfaces: Techniques and Effective Practices*, pp. 1-17, Jan. 2009.

[10] Papastergiou, M., *Digital Game-Based Learning in High School Computer Science Education: Impact on Educational Effectiveness and Student Motivation*, Computers and Education, **52**(1), pp. 1-12, Jan 2019.

[11] Enes, B., *A Brief Overview on Gamification History, Medeniyet University*, https://www.researchgate.net/publication/339594255_A_Brief_Overview_on_ Gamification_History. (10 January 2021)

[12] Denny, J., *The History of Gamification: From the Very Beginning to Right Now*, https://www.growthengineering.co.uk/history-of-gamification (13 January 2021).

[13] Deterding, S., Sicart, M., Nacke, L., O'Hara, K. & Dixon, D., *Gamification: Using Game Design Elements in Non-gaming Contexts*, Proceedings of the 2011 Annual Conference Extended Abstracts on Human Factors in Computing Systems, pp. 2425-2428, Apr. 2011.

[14] Alvarez, J., Djaouti, D., Rampnoux, O. & Alvarez, V., *Serious games market: (from 1950's to 2000's)*, http://serious.gameclassification.com/files/articles/sgc_report_03-11. (13 January 2021)

[15] Sanmugam, M., Mohamed, H., Abdullah, Z., Zaid, N. & Baharuddin, A., *Gamification and Serious Games: The Enigma and the Use in Education*, 3rd International Seminar on Quality and Affordable Education, Nov. 2014.

[16] Anastasiadis, T., Lampropoulos, G. & Siakas, K., *Digital Game-based Learning and Serious Games in Education*, International Journal of Advances in Scientific Research and Engineering, **4**(12), pp. 139-144, Dec 2018.

[17] Bergeron, B., *Learning and Retention in Adaptive Serious Games*, Studies in Health Technology and Informatics, pp. 26-30, Jan 2008.

[18] Bellotti, F., Kapralos, B., Lee, K., Moreno-Ger, P. & Berta, R., *Assessment in and of Serious Games: An Overview*, Advances in Human-Computer Interaction, 136864, Feb 2013.

[19] Klerk, S. & Kato, P., *The Future Value of serious Games for Assessment: Where Do We Go Now?*, Journal of Applied Testing Technology, 18, pp. 32-37, Dec 2017.

[20] Zolotaryova, I. & Plokha, O., *Serious Games: Evaluation of the Learning Outcomes*, 13th International Conference on Modern Problems of Radio Engineering, Telecommunications and Computer Science (TCSET), Lviv, pp. 858-862, Feb 2016.

[21] Aleem, S., Capretz, L. & Ahmed, F., *Game Development Software Engineering Process Life Cycle: A Systematic Review*, Journal of Software Engineering Research and Development, 4, 6, Nov 2016.
[22] Blitz Games Studios, Project Lifecycle, http://www.blitzgames studios.com/blitz_academy/game_dev/project_ lifecycle. (18 March 2020)
[23] Chandler, H., *Game Production Handbook*, Sudbury: Jones and Bartletts Publishers, 2009.
[24] Hendrick, A., *Project Management for Game Development*, http://mmotidbits.com/2009/06/15/project-management-for-game-development. (18 March 2020)
[25] Braad, E., Sandovar, A. & Žavcer, G., *Processes and Models for Serious Game Design and Development*, in Dörner R., Göbel S., Kickmeier-Rust M., Masuch M., Zweig K. (eds.), *Entertainment Computing and Serious Games*, Lecture Notes in Computer Science, pp. 92-118, Springer International, Oct 2016.
[26] Saavedra, B., Rodriguez. F., Arteaga, J., Salgado, R. & Collazos., C., *A Serious Game Development Process Using Competency Approach*, International Conference on Human Computer Interaction, pp. 1-9, Sep. 2014.
[27] Lotfi, E., Belahbib, A. & Bouhorma, M., *Adaptation of Rapid Prototyping Model for Serious Games Development*, Journal of Computer Science and Information Technology, **2**(2), pp. 173-183, July 2015.
[28] Barbosa, A., Pereira, P., Dias, J. & Frutuoso, G., *A New Methodology of Design and Development of Serious Games*, International Journal of Computer Games Technology, **2014**, 817167, Jun 2014.
[29] Freitas, S. & Liarokapis, F., *Serious Games: A New Paradigm for Education?*, in Ma, M., Oikonomou A. & Jain L. (eds.), *Serious Games and Edutainment Applications*, London: Springer, pp. 9-23, Oct 2011
[30] Ramadan, R. & Widyani, Y., *Game Development Life Cycle Guidelines*, International Conference on Advanced Computer Science and Information Systems, pp. 95-100, Sep 2013.
[31] Roedavan, R., Pratondo, A., Utoro, R. & Sujana, A., *Adaptation Atomic Design Method for Rapid Game Development Model*, International Journal of Applied Information Technology, **4**(2), pp. 93-102, May 2021.
[32] Plass, J.L., Homer, B. & Kinzer, C., *Foundations of Game-Based Learning, Educational Psychologist*, **50**(4), pp. 258-283. Oct 2015.
[33] Plass, J.L. & Kaplan, U., *Emotional Design in Digital Media for Learning*, in S. Tettegah & M. Gartmeier (eds.), *Emotions, Technology, Design, and Learning*, pp. 131-162. New York, NY: Elsevier, Oct. 2015.
[34] Hoffman, B. & Nadelson, L., *Motivational Engagement and Video Gaming: A Mixed Methods Study*, Educational Technology Research and Development, **58**, pp. 245-270, Sep. 2009.

[35] Kalyuga, S. & Plass, J.L., *Evaluating and Managing Cognitive Load in Games*, in Ferdig, R. (ed.), *Handbook of Research on Effective Electronic Gaming in Education*, pp. 719-737, USA: Kent State University, July 2008.

[36] Turkay, S., Hoffman, D., Kinzer, Charles. K., Chantes, P. & Vicari, C., *Toward Understanding the Potential of Games for Learning: Learning Theory, Game Design Characteristics, and Situating Videogames*, Classrooms, Computers in the Schools, **31**(1-2), pp. 2-22, Apr. 2014.

[37] Roedavan, R., Pratondo, A., Pudjoatmodjo, B. & Siradj, Y., *Zetcil: Game Mechanic Framework for Unity Game Engine*, International Journal of Applied Information Technology, **3**(2), pp. 96-105, Feb 2020.

[38] Bailey, R., Allen, Janet, M., Farrokh, P. & Emblemsvåg, J., *Validating Design Methods & Research: The Validation Square*, ASME Design Theory and Methodology Conference, **4**(12), pp. 379-390, Jan 2000.

[39] Laugwitz B., Held T. & Schrepp M., *Construction and Evaluation of a User Experience Questionnaire*, in Holzinger, A. (ed.), *HCI and Usability for Education and Work*, pp. 63-76, Berlin, Springer-Verlag Berlin Heidelberg, Nov. 2008.

[40] Schrepp M., Hinderks A. & Thomaschewski J., *Applying the User Experience Questionnaire (UEQ) in Different Evaluation Scenarios*, in Marcus, A.(ed.), *Design, User Experience, and Usability, Theories, Methods, and Tools for Designing the User Experience*, pp. 383-392, Switzerland, Springer International Publishing, June 2014.