

# The Development of “Forest Ranger” as a 2D Serious Game Application to increase Awareness against Illegal Logging

Amri Yusoff<sup>1,\*</sup>, Shahrizuan Shafiril<sup>1</sup>

<sup>1</sup>Faculty of Art, Computing and Creative Industry, Sultan Idris University of Education, Perak, Malaysia

\*Corresponding Author: Amir Yusoff

**Abstract** This study aims to develop a 2D game application which focuses on increasing the public awareness against illegal logging that leads to the bigger problem of forest deforestation. This serious game application not only served as an entertainment game but also to educate everyone. Hence by role-playing inside the game will create the cognitive perception of protecting the forest from any activities that would harm and give irreversible changes in the forest. The methodology of this application is based on ADDIE model and it involves the use of specialized software and hardware in developed the fully functional prototype. The findings of this fully game apps will create a gameplay of suspension of disbelief for the gamer when compared to the real situation and behaviours performed inside the forest. At the present time, the game application was partially developed which contains all the information regarding situations of the loggers in the forest and how the player interacts to prevent the logging activities from happening.

**Keywords** game-based learning, ADDIE model, illegal logging, serious game, educational gaming

## I. INTRODUCTION

The depletion of forest in Malaysia currently can be considered as a serious matter especially involving protected rain forest. If no action been taken, it will lead to a bigger threat such as landslide, global warming and forest fires. It is been stated by [1] that if the temperature became higher while the humidity decrease and the wind become strong, it will create forest fires that will spread from one location to others thus create a major damaged to the forest. Not only that, some of the illegal loggers have been spotted at some location in the forest cutting the tree for logging purpose. Logging activities can bring development to the infrastructure. For instance, deforestation that been carried out for the construction of the road, the North-South highway, hospitals, schools and infrastructure construction, etc. With transportation system, one could intensify activities for the purpose of logging exportation. As a result, it has created widespread environmental damage, irreversible climate change, contamination of air and surrounding rivers, recurrent avalanches, as well as deterioration of the colony regions and

the living conditions among Aborigines. Furthermore, an interesting study revealed that half of the land on the Earth has been used up by human. Besides, nearly 30% of carbon dioxide occasioned from human acts has filled up the earth. Thus, crucial inquiry has to be carried out urgently in order to conserve the ecosystem of our Earth. In fact, two methods are available to prevent illegal logging activity. The first method is enforcing stricter forest preservation regulation to punish those who commit it, while the second method is tightening the observation of illegitimate forest harvest. Nonetheless, conventional method for monitoring large-scale forests, which saves time and labor resources is by keeping the ranger manually patrolling the area. Moreover, the desolate state of the forest ecosystem is also making it too harsh to constant patrol. Therefore, the purposes of this study had been to maintain the ecosystem of the Earth by preserving and regulating our treasured forest. The research depicts the development of a game based learning which could help to create an awareness regarding preserving the rainforest.

## II. BACKGROUND

The Malaysian government had put up a momentous effort by inaugurating “Green the Earth: One Citizen, One tree” campaign in April 2010, which aimed to plant 26 million trees by 2014 and also capitalized a huge sum of money (RM60 million) in a Central Forest Spine (CFS) project that linked four major forest complexes in Malaysia for preserving forests, animals, and plant species in the country. Of late, numerous logging activities in these areas (Lojing and Royal Belum Forests) have been exposed, for instance, illegal logging, jungle clearing and hill cutting that made way for farming activity, as well as mixed development projects. Therefore, this study is vital in supporting the nation plan. This study experimented upon and developed an automated multifunctional remote monitoring model for a sustainable forest management, which could be used for protecting and monitoring purposes from afar and immediate response can be made if disturbance is detected in the rainforest.

One of the main aims of this game development is to create an awareness among communities regarding the after effect of deforestation as a result of illegal logging. These illegal activities not only will lead to the depleted forest but also can endanger the flora and fauna habitats. According to [2] scientists, educators and policymakers continue to face

challenges when it comes to finding effective strategies to engage the public on climate change. They argued that games on the subject of climate change are well-suited to address these challenges because they can serve as effective tools for education and engagement. In the article written by [3], they discuss GREENIFY, a real-world action game designed to teach adult learners about climate change and motivate informed action. A pilot study suggests that the game fostered the creation of peer-generated user content, motivated informed action, created positive pressure, and was perceived as a fun and engaging experience. This paper [4] addresses the integration of artificial life simulations with interactive games-based technologies and describes how the results are being exploited not only for scientific visualization and education but also for fundamental research into simulation complexity, focusing on the behavioural representation of species in fragile or long-vanished landscapes and ecosystems.

In addition, this study can be enhanced by developing a series of games applications to advise the young generation about maintaining the environment. The development of a series of games as teaching aids can make aware our future generation about the depletion of rainforest and its impact upon the environment. Most importantly, this research generated numerous outcomes. Thus, it is hoped that the research could produce output that would benefit both government and private sectors through the interactions between end users and their end products.

### III. FACTORS AND EFFECT OF ILLEGAL LOGGING

#### A. Factors That Promote Logging

##### a) *Equatorial forest*

Malaysia is a country that has an area of equatorial large-rainforest. 29% of the forest covers Peninsular Malaysia, 22% Sabah and 49% Sarawak. Many of the valuable forest wood supply can be located here such as Cengal, Meranti, Keruing and Merbau.

##### b) *High Demand*

The domestic market for the sawmill, furniture industry and paper-making factory. The factory located in Malaysia's Pahang, Sabah and Sarawak and also the overseas market in the form of plywood, logs and sawn timber. The timber is exported to foreign countries such as Japan, Thailand and Singapore.

##### c) *Government policy*

The government encourages logging activities by setting up agencies such as the Timber Industry Board, which aims to promote new marketing. There are FRIM also that been conducting research and development of trees. For example treatment, such as pine trees, batai and akarsia. Not only that, the Forestry Department was set up to monitor illegal logging and doing replanting activities.

##### d) *Job opportunities*

There is almost 2.4 million resident in Malaysia who have jobs in the logging sector. In addition, employment opportunities exist, such as factory workers, timber processing, furniture factory workers and drivers in the transportation sector. This jobs opportunity in this industry would reduce unemployment. When people have a steady job, a source of increased revenue resulting in high purchasing power and indirectly improve the living standards of the population.

##### e) *Source of revenue*

The logging sector is one of the primary industries that have the potential to increase country revenue source. This matters because of the results of exported logging to foreign countries like Japan, Singapore and Thailand. The prices for logs are really high in the international market which contributed to a source of revenue through the inflow of currency foreign.

##### f) *City development*

Logging activities led to the creation of an area of New Testament. With the construction of factories, it is to encourage the development of city where the residents been provided jobs opportunities. For example, a sawmill in Kuantan (Pahang), Sandakan (Sabah), Kuala Lipis (Pahang) and Gua Musang (Kelantan).

#### B. Effect of Logging towards Environment

##### a) *Temperature Rising*

Deforestation of logging activities increases in temperature due to the absence of a protective barrier. These will prevent extreme sun and excess carbon dioxide in the air humidity of the atmosphere. The effects of it come in the condition of decrease release water vapours into the air through transpiration and the surrounding air becomes dry (Dry Air).

##### b) *Extinction of flora and fauna*

When forests are destroyed for logging, various species of flora and fauna in that habitat also been affected by it. Not only loss, impaired ecosystem food chain can be affected. Some of it causes extinction such as tigers, elephants and monkey. In addition to the extinction of fauna such as Merbau trees.

##### c) *Landslides*

When logging is done to excess, soil erosion and landslide. This is because the surface has been exposed to water erosion during heavy rain. Rainfall will cause runoff surface erodes the soil surface layer of silt, mud will be entered into the river. Thus, the river became shallow, murky mud and flooding in low-lying areas.

##### d) *Water Pollution*

Deforestation for logging activities caused erosion runoff occurs and brings in silt and mud into the river. The River became shallow and aquatic ecosystems become unbalance. For instance, Pahang and Kelantan River.

e) The destruction of water catchment areas

Deforestation for logging will reduce the rate of water infiltration into the soil and concurrently reduced the water level in the ground. This will affect watersheds and water supply to rivers, lakes, ponds and forests swamp.

f) Landscape changes

Woodcutter that rampantly chopping all the trees will cause the land to become swipe-clean without anything left. Also, there is a relatively dry and a barren primary forest. This caused the changes from secondary forests and next to a leisure area.

## IV. SERIOUS GAME

A serious game or also known as the applied game is a game that were designed for a primary purpose other than pure entertainment. The "serious" adjective is generally prepeded to refer to video games used by industries like defence, education, scientific exploration, health care, emergency management, city planning, engineering, and politics. The idea shares aspects with simulation generally, including flight simulation and medical simulation, but explicitly emphasizes the added pedagogical value of fun and competition[5].

According to [6], the concept of the "serious game" has only recently entered the vocabulary of educators to identify a game that has an educational purpose [7,8], even though digital games since their early days have had a close relation with the education and teaching environment In the current games market, three types of gaming technologies seem particularly promising for supporting the dissemination of gaming in areas other than a pastime:

- Casual browser games
- Real-time 3D engines
- Massive multiplayer online environments (virtual worlds)

This distinction is merely analytical, as a single game can feature all three aspects (e.g. Battlestar Galactica Online), but often a game specializes in one single aspect (e.g. Heavy Rain) or two of them (e.g. World of Warcraft). Many of the existing serious digital games are based on one or more of these gaming technologies, but all of them are powerful but not necessary tools to build serious games; indeed, it is possible to build a totally engaging serious game without including in its design any of those aspects 3. The crucial features of a serious game are the "game mechanics": simple or complex rules that shape the game experience.

The use of game mechanics outside of pure pastime use is the focus of the concept of gamification, considered to be the use of game mechanics in non-game situations [9]. The concept of gamification originates in the areas of marketing

and has often been criticized because of the focus on trying to sell more products through the means of making customers more loyal [10]. Furthermore, it has been said that marketing-based gamification might lead to forms of corporate surveillance toward customers through the means of gamified feedbacks [11,12]. Another form of critique argues that adding game mechanics to any application and pretending it will deliver magic communicative results is a very poor way of using game design for designing non-gaming artefacts [13].

## V. METHODOLOGY

The ADDIE model is the generic process traditionally used by instructional designers and training developers. The five phases—Analysis, Design, Development, Implementation, and Evaluation—represent a dynamic, flexible guideline for building effective training and performance support tools. While perhaps the most common design model, there are a number of weaknesses to the ADDIE model which have led to a number of spin-offs or variations. It is an Instructional Systems Design (ISD) model. Most of the current instructional design models are spin-offs or variations of the ADDIE model; other models include the Dick & Carey and Kemp ISD models. The goal of this research is to have a standard model for designing educational games. It should guide the designer to state clear learning goals and take the existing teaching methods into account. Following this method the designer should acquire the necessary background knowledge to develop a game that helps students reach all designed learning tasks

One commonly accepted improvement to this model is the use of rapid prototyping. This is the idea of receiving continual or formative feedback while instructional materials are being created. This model attempts to save time and money by catching problems while they are still easy to fix. Instructional theories also play an important role in the design of instructional materials. Theories such as behaviourism, constructivism, social learning and cognitivism help shape and define the outcome of instructional materials. In the ADDIE model, each step has an outcome that feeds into the subsequent step.

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| Analysis > Design > Development > Implementation ><br>Evaluation |
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Fig.1. ADDIE model phase

### 1) Analysis Phase

In the analysis phase, instructional problem is clarified, the instructional goals and objectives are established and the learning environment and learner's existing knowledge and skills are identified.

### 2) Design Phase

The design phase deals with learning objectives, assessment instruments, exercises, content, subject matter analysis, lessons planning and media selection. The design phase should be systematic and specific. Systematic means a logical, orderly method of identifying, developing and evaluating a set of planned strategies targeted for attaining the project's goals. Specific means each element of the instructional design plan needs to be executed with attention to details. The primary focus of this phase is to refine the decisions that had been discovered in the functional design document. Interface and interactions were obtained from previous indicated classes and interfaces that separated them into two parts of logical module. This phase's output is a formal design document.

### 3) Development Phase

The development phase is where the developers create and assemble the content assets that were created in the design phase. Programmers work to develop and/or integrate technologies. Testers perform debugging procedures. The project is reviewed and revised according to any feedback given. The main focus of this phase is to test each unit of previously developed codes as well as to test the overall system. Besides, this phase is the basic type of testing that includes unit test and integration test. Testing the functionality of the code unit is the reason Unit Test was developed, where it aims to make sure that it performs its required task. On the other hand, the system will be tested as an overall for Integration testing since it only focuses on the results of specific unit combinations of code and therefore, expected results will be validated.

### 4) Gamemaker Studio

GameMaker accommodates the creation of cross-platform and multi-genre video games using drag and drop action sequences or a sandboxed scripting language known as Game Maker Language, which can be used to develop more advanced games that could not be created just by using the drag and drop features. GameMaker was designed to allow novice computer programmers to be able to make computer games without much programming knowledge by use of these actions.

### 5) Adobe Photoshop

Adobe Photoshop is the predominant photo editing and manipulation software on the market. Its uses range from the full-featured editing of large batches of photos to creating intricate digital paintings and drawings that mimic those done by hand.

### 6) RPG Maker VX

RPG Maker VX allows the user to make the role-playing games by being one of the easiest game engine software ever developed. With its enhanced auto-tile capabilities, quick event creation, and dungeon generator, you can have a game ready to play faster than ever before.

### 7) Implementation Phase

During the implementation phase, a procedure for training the facilitators and the learners is developed. The facilitators' training should cover the course curriculum, learning outcomes, a method of delivery, and testing procedures. Preparation of the learners includes training them on new tools (software or hardware), student registration. This is also the phase where the project manager ensures that the books, hands-on equipment, tools, CD-ROMs and software are in place and that the learning application or Web site is functional. The code for the prototype will be tested first before it can be implemented toward the end-prototype. The reason is to make sure that the code can be fully functional from any error or debug.

### 8) Evaluation Phase

The evaluation phase consists of two parts: formative and summative. Formative evaluation is present at each stage of the ADDIE process. Summative evaluation consists of tests designed for domain-specific criterion-related referenced items and providing opportunities for feedback from the users. This phase mainly focuses on testing the overall system in relation to the list of desired operating environments and project requirements. It is also to focus on testing the project that has been completed over the user so that one can prove if their specifications are met according to their original requirements. This phase is also in need of changes to be made and to validate the correctness of the requirements. Furthermore, any problems that were unresolved in the previous phase are managed in this stage.

## VI. RESULT

We develop the implementation of the game which includes creating an artistic style and programming the game itself. As platform for creating the game itself we use Game Maker 8.1 by YoYoGame as this program offers a wide variety of tools for creating games, especially in 2D. Its many tools allow for fast prototyping, while its powerful scripting language allows for altering almost any aspect of the game.

The development of this serious games application almost 85% complete before it can be implemented. There are only a slight works that need to be done in order to finish it. The figure below portrayed the current works of this application. As everyone can see, Fig. 2(a) illustrated the gameplay of the application which indicates the hero's in this games that is the forest ranger which holding the tranquillizer gun walking around the forest monitoring the surroundings if there are any illegal activities happening within it.



Fig. 2(b). A logger trying to chop the trees

If the all of the trees were destroyed, the game will end and goes to the “Game Over” screen. Fig. 2(c) portrayed another enemy that will randomly spawn that is the corrupt ranger which took a bribe money from the loggers to prevent the heroes from saving the trees from being destroyed. The only way for the heroes to stop the corrupt ranger officer from continuing his jobs is to shoot the corrupt ranger using tranquilizer gun the same as to prevent the loggers.



Fig. 2(a). Forest Ranger gameplay

Fig. 2(b) shows there are loggers currently chopping out the trees. The indicators above the trees indicated the health bar of the trees, at a certain time, it will slowly decrease which then after the health been depleted, the trees will change it instance to tree’s stomp.

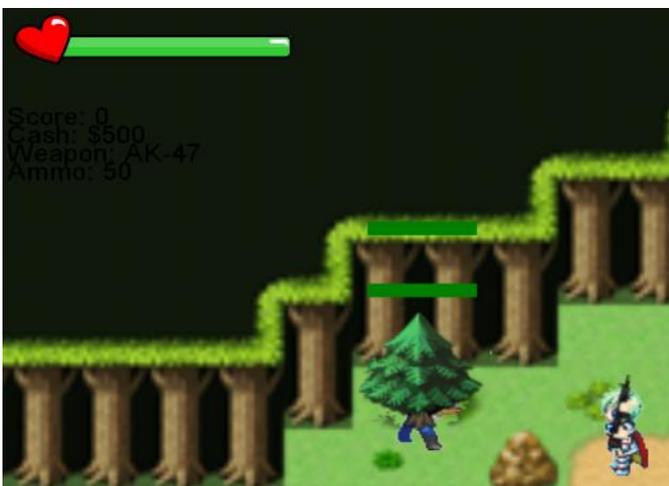


Fig. 2(c). Corrupt rangers preventing the main character from saving the forest

By shooting the spawned corrupt ranger, the player will increase the current score and coin gained. The coins that been gathered can be used to buy an ammo or another tranquillizer guns with different attributes. Player can move from location of the forest to another part of the forest. All parts of the forest are different from another as the enemy will increase and the speed and the time of the forest to be depleted become faster than before.

## VII. CONCLUSION

The paper presented the development of Forest Ranger application which intends to create awareness against illegal logging activities based on the principle of the serious game and learning theory of behaviourisms, cognitive and constructivism. We defined the development of the game based ADDIE modelling. The usability study was done by a multidisciplinary group of participants, who suggested a number of positive comments and improvements for future development. In the future, we will gamify more Forest Ranger missions. We are currently working on the gamification of Forest Ranger extra tasks.

We would like users to learn about the effects of the depleted forest, which would be important to the prevent deforestation of the rainforest. We would like to improve the game according to the comments we received. We plan to modify the game for elementary and middle school students by creating child-friendly controls and interfaces (e.g., replacing text-based instructions with graphical tutorials). We also plan to perform a quantitative assessment to identify the relationship among the number of times of play, the improvement of play score, and learning efficiency.

Game design has still not seeped into the training scene as it should have. The reasons lie in the lack of a framework that combines together the elements of game design and those of instruction design. Several researchers still favor the ADDIE model when designing educational video games. This model is well known to cover a detailed and a complex view of both conceptual and technical levels of a video game design. However, it misses the game design principles that represent that game aspect of learning. Without a gameplay, instructions become only learning at best, and fail to deliver the promised motivation through entertainment.

## REFERENCES

- [1] De Gloria, A., Bellotti, F., & Berta, R. (2014). Serious Games for education and training. *International Journal of Serious Games*, 1(1).
- [2] Kowert, R., & Quandt, T. (2017). *New Perspectives on the Social Aspects of Digital Gaming: Multiplayer 2*. Routledge.

- [3] Wouters, P., & Van Oostendorp, H. (2013). A meta-analytic review of the role of instructional support in game-based learning. *Computers & Education*, 60(1), 412-425.

- [4] Mortara, M., Catalano, C. E., Bellotti, F., Fiucci, G., Hourv-Panchetti, M., & Petridis, P. (2014). Learning cultural heritage by serious games. *Journal of Cultural Heritage*, 15(3), 318-325.

- [5] Wouters, P., Van Nimwegen, C., Van Oostendorp, H., & Van Der Spek, E. D. (2013). A meta-analysis of the cognitive and motivational effects of serious games.

- [6] Dicheva, D., Dichev, C., Agre, G., & Angelova, G. (2015). Gamification in education: A systematic mapping study. *Journal of Educational Technology & Society*, 18(3).

- [7] Huang, W. H. D., & Tettegah, S. Y. (2014). Cognitive load and empathy in serious games: A conceptual framework. In *Gamification for Human Factors Integration: Social, Education, and Psychological Issues* (pp. 17-30). IGI Global.

- [9] Heins, M. C. (2017). Video games in education.

- [10] Wu, J. S., & Lee, J. J. (2015). Climate change games as tools for education and engagement. *Nature Climate Change*, 5(5), 413-418.

- [11] Elson, M., & Ferguson, C. J. (2014). Twenty-five years of research on violence in digital games and aggression. *European Psychologist*.

- [12] Catalano, C. E., Luccini, A. M., & Mortara, M. (2014). Best practices for an effective design and evaluation of serious games.

- [13] Charsky, D. (2010). From edutainment to serious games: A change in the use of game characteristics. *Games and culture*, 5(2), 177-198.

- [00] Arnab, S., Lim, T., Carvalho, M. B., Bellotti, F., De Freitas, S., Louchart, S., ... & De Gloria, A. (2015). Mapping learning and game mechanics for serious games analysis. *British Journal of Educational Technology*, 46(2), 391-411.

- [00] Backlund, P., & Hendrix, M. (2013, September). Educational games-are they worth the effort? A literature survey of the effectiveness of serious games. In *Games and virtual worlds for serious applications (VS-GAMES), 2013 5th international conference on* (pp. 1-8). IEEE.

- [00] Baralt, A., & Ritzhaunt, A. D. (2015). Reality is Broken: Why Games Make Us Better and How They Can Change the World.

- [00] Baranowski, T., Budav, R., Thompson, D., Lyons, E. J., Liu, A. S., & Baranowski, J. (2013). Developing games for health behavior change: Getting started. *GAMES FOR HEALTH: Research, Development, and Clinical Applications*, 2(4), 183-190.

- [00] Barata, G., Gama, S., Jorge, J., & Goncalves, D. (2013, September). Engaging engineering students with gamification. In *Games and Virtual Worlds for Serious Applications (VS-*

GAMES), 2013 5th International Conference on (pp. 1-8). IEEE.

[00] Bellotti, F., Kapralos, B., Lee, K., Moreno-Ger, P., & Berta, R. (2013). Assessment in and of serious games: an overview. *Advances in Human-Computer Interaction*, 2013, 1.

[001] Boas, Y. A. G. V. (2013, January). Overview of virtual reality technologies. In *Interactive Multimedia Conference* (Vol. 2013).

[00] Boyle, E. A., Hainey, T., Connolly, T. M., Gray, G., Earp, J., Ott, M., ... & Pereira, J. (2016). An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games. *Computers & Education*, 94, 178-192.

[001] Boyle, E. A., Hainey, T., Connolly, T. M., Gray, G., Earp, J., Ott, M., ... & Pereira, J. (2016). An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games. *Computers & Education*, 94, 178-192.

[001] Cairns, P., Cox, A., & Nordin, A. I. (2014). Immersion in digital games: review of gaming experience research. *Handbook of digital games*, 1, 767.

[001] Carvalho, M. B., Bellotti, F., Berta, R., De Gloria, A., Sedano, C. I., Hauge, J. B., ... & Rauterberg, M. (2015). An activity theory-based model for serious games analysis and conceptual design. *Computers & education*, 87, 166-181.

[00] Clark, D. B., Tanner-Smith, E. E., & Killingsworth, S. S. (2016). Digital games, design, and learning: A systematic review and meta-analysis. *Review of educational research*, 86(1), 79-122.

[001] DaCosta, B., Seok, S., & Kinsell, C. (2019). Mobile game-based learning. In *Advanced Methodologies and Technologies in Modern Education Delivery* (pp. 809-824). IGI Global.

[00] Dawley, L., & Dede, C. (2014). Situated learning in virtual worlds and immersive simulations. In *Handbook of research on educational communications and technology* (pp. 723-734). Springer, New York, NY.

[001] Erhel, S., & Jamet, F. (2013). Digital game-based learning: Impact of instructions and feedback on motivation and learning effectiveness. *Computers & Education*, 67, 156-167.

[00] Fullerton, T. (2014). Game design workshop: a playercentric approach to creating innovative games. AK Peters/CRC Press.

[001] Girard, C., Ecalle, J., & Magnan, A. (2013). Serious games as new educational tools: how effective are they? A meta-analysis of recent studies. *Journal of Computer Assisted Learning*, 29(3), 207-219.

[00] Kirubaharan, D. V., Sunder, A. J. C., Ramesh, S. M., & Dhinakar, P. (2014). Intruder Detection and Forest Fire Alert System with Using Wireless Sensor Network. *International Advanced Research Journal in Science, Engineering and Technology*.

[001] Landers, R. N. (2014). Developing a theory of gamified learning: Linking serious games and gamification of learning. *Simulation & Gaming*, 45(6), 752-768.

[001] Landers, R. N., & Armstrong, M. B. (2017). Enhancing instructional outcomes with gamification: An empirical test of the Technology-Enhanced Training Effectiveness Model. *Computers in Human Behavior*, 71, 499-507.

[00] Lee, J. J., Ceyhan, P., Jordan-Cooley, W., & Sung, W. (2013). GREENIFY: A real-world action game for climate change education. *Simulation & Gaming*, 44(2-3), 349-365.

[001] Maver, I., Bekebrede, G., Hartevelde, C., Warmelink, H., Zhou, O., van Ruijven, T., ... & Wenzler, I. (2014). The research and evaluation of serious games: Toward a comprehensive methodology. *British Journal of Educational Technology*, 45(3), 502-527.

[12] Mayer, I., Bekebrede, G., Hartevelde, C., Warmelink, H., Zhou, Q., Ruijven, T., ... & Wenzler, I. (2014). The research and evaluation of serious games: Toward a comprehensive methodology. *British Journal of Educational Technology*, 45(3), 502-527.

[001] Nagyvörög, K., Urbán, R., Farkas, J., Griffiths, M. D., Zilahy, D., Kökönevi, G., ... & Harmath, F. (2013). Typology and sociodemographic characteristics of massively multiplayer online game players. *International journal of human-computer interaction*, 29(3), 192-200.

[00] Qian, M., & Clark, K. R. (2016). Game-based Learning and 21st century skills: A review of recent research. *Computers in Human Behavior*, 63, 50-58.

[00] Romero, M., Usart, M., & Ott, M. (2015). Can serious games contribute to developing and sustaining 21st century skills?. *Games and Culture*, 10(2), 148-177.