

# Design of a serious game to strengthen the immune system against Covid-19

Farida BOUROUMANE  
Laboratory of Engineering Sciences  
Faculty Polydisciplinaire Taza,  
Morocco  
farida.bouroumane@usmba.ac.ma

Abderrahim SAAIDI  
Laboratory of Engineering Sciences  
Faculty Polydisciplinaire Taza,  
Morocco  
abderrahim.saaidi@usmba.ac.ma

Mustapha ABARKAN  
Laboratory of Engineering Sciences  
Faculty Polydisciplinaire Taza,  
Morocco  
mustapha.abarkan@usmba.ac.ma

**Abstract**— Since the onset of the COVID-19 coronavirus, several sectors have been working to understand the virus, the symptoms, and the evolution of the disease. The issues of immunity are currently the subject of various research and studies. A promising approach is to use playful video culture to raise awareness and train players to adopt good eating habits to strengthen the immune system. In this article, we describe a prototype of a serious game about how to strengthen immune defenses in order to fight a coronavirus infection and build an antiviral barrier. This game aims at providing information on the link between food, immunity and the spread of the virus within the human body so it illustrates risky behaviours so as to raise awareness of the modifications to be adopted to improve the immune system.

**Keywords**— *Serious Game, Covid-19, Virus, Immune System, Ludic Aspect.*

## I. INTRODUCTION

COVID-19 is a highly contagious respiratory disease, first found in Wuhan, China on November 17, 2019. This is the first pandemic on a global scale; it had swept all regions of the world without exception with a terrible human toll. According to the authors [1], COVID-19 causes symptoms typical of acute respiratory diseases, such as cough, fever, dyspnea and fatigue, often accompanied by loss of smell or taste. Benjamin Djoudalbaye [2], Chadian doctor and expert in infectious diseases explains that "the coronavirus is an RNA virus. The particularity of these viruses is precisely that they multiply. At each number of replications, there are errors copy and these copy errors can potentially induce mutations ". As COVID-19 continues to cause deaths around the world, doctors, researchers and scientists around the world are working together to find solutions. While most studies have focused on vaccine and treatment research. As COVID-19 continues to cause deaths around the world, doctors, researchers and scientists around the world have supported the needed food strategies to support immunity. It is well known that, the immunity weakens and the body becomes more vulnerable to infections with age or disease. Epidemiological studies show that diet, smoking, sleep, physical activity, stress, quality of human relationships and living environment all influence the quality of the immune response [3] [4]. Therefore, it is necessary to understand the functioning of our immune system, protect it and strengthen it. According to author Emily Conover [5], an organism's immune system is a complex biological system consisting of a coordinated set of recognition and defense elements that discriminate the self from the non-self. It is inherited at birth, but autonomous, adaptive and endowed with a great plasticity, it then evolves according to the contacts it has

with microbes or environmental substances foreign to the body. Our immune system is a real war machine fighting undesirable invaders. When he is healthy, no infection can resist him. However, a small weakness causes a disturbance in the defenses of our organism. For several years, extensive research on nutrition has shown that nutrition plays a key role in preventing and curing infections. Moreover, it reduces the risk of death. Indeed, according to the authors [6], poor nutrition is a major cause of mortality and disability worldwide. Currently, digital technology has invested most areas of our lives. In addition, because of the containment measures imposed by COVID-19, the video game industry is experiencing the strongest growth in the world. Thus, the number of players has grown rapidly. Kristopher Alexander, a video game professor at Ryerson University in Toronto, says, "What this pandemic has done is highlight some of the most positive aspects of video games that are often lacking in the media." Following the research work of Prensky [7], "People play games because the process of game playing is engaging [...] because they are challenging and relaxing. This formulation seems very close to that magical state of motivation some refer to as flow." This article is devoted to study and analyze the awareness of people through the use of the playful aspect of a serious game, on the existing relations between the general functioning of the immune system, the diet and the spread of the virus within the human organism. We proposed the idea of a serious game to motivate players to adopt good eating habits, support the immune system, protect this protected, and better defend themselves. This game allows players to travel through the human body and discover food solutions that strengthen immune defenses.

After this introduction, the second section describes the state of the art, where some video games related to the theme of Covid-19 are presented. The third section is reserved for presenting the elements of the central idea. The fourth section is presented the proposed game methodology. The last section is a comparative study between the proposed idea and another game of the same theme.

## II. RELATED WORKS

Currently, global research is looking for a solution to eradicate COVID-19 as it spreads at high speeds around the globe. The response from the video game industry has been encouraging. To better understand how the COVID-19 virus works, researchers at the University of Washington relied on FOLDIT, a serious game released in 2008. It uses protein folding to understand the structure of each amino acid sequence and how it works to target it with drugs. The University of Washington team has added an extension on

COVID-19, allowing players to understand how the coronavirus works. This means designing a new protein that will bind to the coronavirus's advanced protein to block the bonds and stop the infection in the body. With the reopening of schools, the training, youth and culture department of the Canton of Vaud (Switzerland) headed by State Councilor Cesla Amarelle, produced between April 29 and May 9 a serious game CoronaQuest to learn respect for barrier gestures by young people in order to limit the spread of the epidemic. This free online card game makes it possible to raise awareness of health practices for a return to class in a secure environment and offered in 10 languages (French, English, German, Italian, Portuguese, Spanish, Albanian, Croatian, Serbian and Bosnian) and downloadable on the smartphone, tablet and computer. In order to understand and anticipate the psy-chosociological, economic and social effects of the coronavirus on businesses, In order to understand and anticipate the psy-chosociological, economic and social effects of the coronavirus on businesses, the Lyon-based economic and social explorer brand has developed a serious multiplayer range, which took place on April 1, 2020, for two hours. Participants will access a platform representing the reality of a business. Faced with the health crisis, they will have to make choices: partial unemployment, teleworking, use of aid, closure, dismissal, prospecting ... When the crisis subsides, it will be a question of making a new start and taking stock of this adventure. Global, now, in the unprecedented context of a global pandemic, the game "Plague Inc. », which has been showing gamers for eight years how a pandemic is spread and how to destroy the world's population by creating an ultra-resistant virus, announced a new game mode, the objective of which is to find out how to stop the COVID-19 virus and save the population.

### III. ELEMENTS OF THE CENTRAL IDEA

In this section, we will present the basic elements of our game idea. The objective is to determine a logical, simple-to-understand, and a basic scenario based on a coherent structure to facilitate the design and implementation of the solution.

#### A. Immune system

The immune system ensures the body's defense against microbes, viruses, toxic substances... its effectiveness to help human body stay healthy. Three successive lines of defense oppose viral infection. The first line is the skin and mucous membranes, which are physical barriers that prevent infection. Then second line is innate immunity, non-specific that occurs within hours of infection. It involves different elements cytokines, sentinels; NK cells, and complement inflammation reaction. The last line is acquired immunity, which effector cells are lymphocytes B and T, to be need a period of several days to set up. Generally, way his immune system is considered as to equip, to make it strong, each player in the team must have effective resistance. Indeed, an immune system resistance is related to good nutrition.

#### B. Nutrition

A nutritious diet and healthy sport are essential to the health of people around the world. In general, malnutrition severely weakens the defenses of our body, which increases the risk of reaching infections but also mortality. In addition, the immune system needs enough nutrients to function properly. Ysabelle Levasseur is a dietician nutritionist member of the French Association of Dieticians Nutritionists (AFDN), explains that «For the immune system to function optimally, it is important to adopt a diet rich in antioxidant vitamins. These vitamins will activate the production of cells of the immune system such as B, T and macrophages that are essential to the production of antibodies that will destroy microbes or bad bacteria ». It should be noted that almost all nutrients in the diet play an important role in maintaining an optimal immune response. As a result, their deficiency or even high consumption can have a negative impact on the state of the immune system and increased susceptibility to various pathogens.

#### C. Virus

Coronaviruses are common RNA viruses that cause digestive and respiratory infections in humans and animals. The cycle of infection of a cell by a virus can be broken down into three main steps: the first step is attachment, penetration, and decapsulation, which lead to the internalization of the viral genome in the target cell. The second step is gene expression and replication, which will, respectively, ensure the synthesis of proteins coded by the viral genome and allow the multiplication of this genome. The final step is the assembly and exit that will lead to the production and release of infectious viral particles, capable of spreading the infection to other cells. In addition, viruses use two mechanisms to persist in host cells: the first strategy is camouflage and the second strategy is sabotage of the lines of defense.

#### D. Serious games to promote good practice

The authors [8] indicate that serious game increases the effectiveness of the rehabilitation process in cognitive therapies, including by improving attention, concentration, motivation and problem solving. Indeed, in order to assess the interest of using serious games to raise awareness and support the general public in the face of this COVID-19 epidemic, an experimental study for students of the Polydisciplinary Faculty of Taza. The 200 students participating in this experiment are external to this research project and have no experience in serious games. Through this study, we sought to collect the expression of both positive and negative perceptions of "serious games". The experimental study was conducted in two distinct phases in the following way: the first stage is devoted to presenting the operation and use of three types of support selected for this study in relation to the Covid-19 theme [Table 1].

TABLE 1: THREE TYPES OF SUPPORT RELATED TO THE COVID-19 THEME.

Production	awareness-raising	Thematic
Florian Proust for Sip (Mar 27, 2020)	Comic strip "Not the coronavirus!".	Help understand and support in the face of the COVID-19 epidemic and the consequences for it.
From the cast of the movie Contagion (Mar 27, 2020)	Video.	Raise awareness of barrier gestures in order to fight the coronavirus pandemic.
The Department of Education, Youth and Culture of the Canton of Vaud (Switzerland) (May 11, 2020)	Serious game «CoronaQuest »	Learn to respect barrier gestures by young people in order to limit the spread of the epidemic.

The second stage of the questionnaire consists of 20 questions divided into 4 sections (knowledge acquisition, reflection, memorization and motivation). Respondents have access to the questions online, the link is sent to them by email. Our study included 200 students with a participation rate of 100%. Also, the response rate to the questionnaire was 100% for these participants. The figure below shows the results of the experimental study.

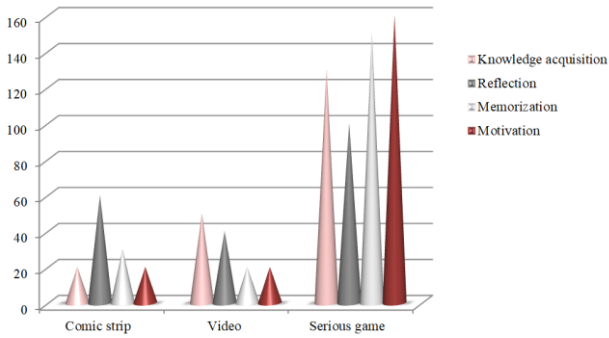


Fig. 1. Results of the experimental study.

Regarding the acquisition of knowledge, the responders were generally satisfied with the serious game, the majority had expressed their agreement on the need for such tools for awareness. Also the majority of responders had specified that the game promotes the reflection of the players, allow at the same time the development of real skills of analysis, anticipation and development of defensive and offensive strategies. In addition, most of the participants specified that playing video games improves the ability to navigate in space and increases memorization skills. Likewise, and contrary to popular belief, video games have a relaxing and calming effect on players by encouraging them to be focused and motivated. Overall, most respondents to the survey believe that serious games add value to awareness. This shows the positive interest of using serious games for awareness in order to limit the spread of the epidemic.

#### IV. GAME METHODOLOGY PROPOSED

To effectively exploit the serious game while maintaining the balance of its pedagogical and ludic qualities, it requires a strong adaptation between the ludic aspect and the serious aspect of the scenario. In addition, it is necessary to check the coherence between the elements of the story in order to facilitate the design and implementation of the game and obtain the best relationship between ludic quality and pedagogical efficiency.

##### A. Proposed main game features

The proposed game serves as an interface to discover, raise awareness and train players to adopt good eating habits to strengthen the immune system. We used the human body in the video game universe as a main environment divided into many zones. The principle of the game is simple, has a fairly realistic aspect, represents the human body in the form of a castle has small towers and a large central tower, a drawbridge that opens to let the allies pass and closes to block the enemies. In this castle, there is a king, families, servants and soldiers. The player's goal is to defeat the

opponent, who is the coronavirus, before it spreads within the castle and attacks all families. Table 2 below presents the components of the castle.

TABLE 2: COMPONENTS OF THE CASTLE.

Castle	Human body
King	Lungs
Families	Liver, Pancreas, Kidneys ,Heart.....
Servants	Spleen, Stomach, Kidneys.....
Soldiers	B lymphocytes, T lymphocytes, NK lymphocytes

The organs of the human body are the living families within the castle represented in the form of houses. The cells of the human body are the members of the family and the molecules are the protection weapons of each family. In this castle, there are stations that show the player the good eating habits to strengthen the soldiers during the war against the enemy. The figure below explains an excerpt from the game history.



Fig. 2. Extract from the proposed story.

The difficulty of writing a game scenario is to allow to diverge and to have several possible sequences, while keeping the ludic aspect. The players start from an initial situation and have a goal to achieve, for example, the players must collect the weapons in each station met to strengthen the soldiers. The figure below provides a general overview of the proposed game scenario.

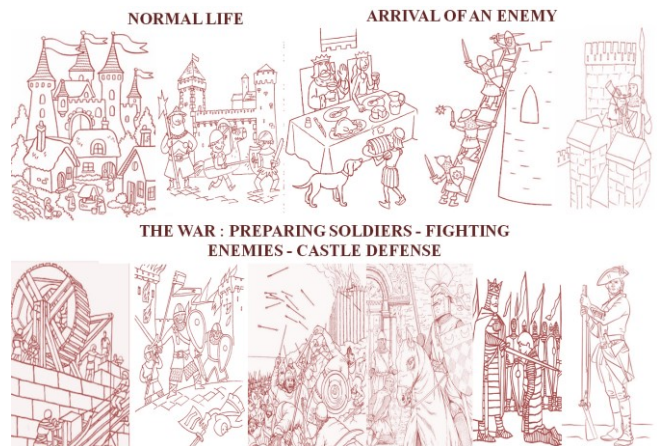


Fig. 3. Proposed game scenario.

The proposed game is called THE MAGIC SOLDIER OF THE HUMAN BODY links to the relationship of the idea of the game with the scenario of the body's immune defense against infectious aggressions. Also, this game is a fighting game offers to fight enemies that based on attack. Table 3 below presents the features of this game.

TABLE 3: PROPOSED GAME FEATURES.

Type of game	Knife-fighting: fighters compete using various weapons such as swords, sticks or axes
Type of gameplay	With button: We press the appropriate button and the counter and its animation are launched whatever happens, even if the opponent has never attacked.
Type of fighters	Powerful fighter: he is a slow but enduring character whose blows are very painful
2D or 3D combat	3D fighting game: more fluid and realistic animations thanks to improved graphics and detailed details.
Multiplayer fighting games	Fighting game based on 3D environment and gameplay, basically limited to two players..

In general, each character (coronavirus, player) has its own characteristics and equipment, which evolve according to the character's experience. In addition, special attacks and equipment are common to all soldiers, but different for the enemy. In each station, there are existed defensive weapons (link to food) to strengthen soldiers during the war against the enemy.

**B. General proposed game architecture**

The interface is the backbone of a video game that serves to simplify the scenario. For the interfaces of THE MAGIC SOLDIER OF THE HUMAN BODY were based on two aspects: the first aspect is the utility aspect, which corresponds to the quality of the technical elements provided to the player by the game. This aspect determines whether the elements used in the space of the game allow the player to achieve his serious objectives. Then the second aspect is the usability aspect, which corresponds to the quality of the player-game interaction, in terms of ease of use of the game. In general, the proposed game architecture allows the player to choose between several possibilities. Indeed, we proposed five different levels of the game. During each level of play the player plays a learning situation by theme, for example, for the first level «INITIAL BALANCE» the players must discover the main principles of the diet, the basic nutritional needs, how to eat well and the benefits of a good diet. The goal is shared happiness in the castle by the distribution of compatible foods for each family (organ of the human body). Table 4 below presents the purpose of each level.

TABLE 4: FIVE LEVELS OF PLAY PROPOSED.

1	2	3	4	5
Initial balance	Disturbance	Imbalance	Restorative action	Restoring balance
Happiness in the castle	Arrival of enemies	Attack on families	Arrival of arms	Stop the enemies

The figure below shows the components of the proposed game architecture.

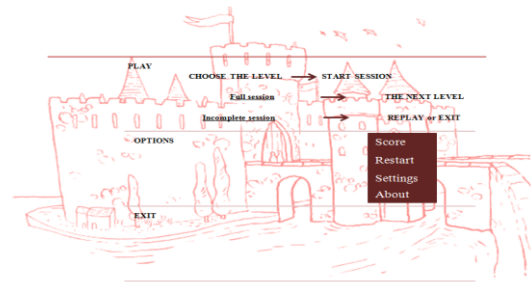


Fig. 4. General game proposed architecture.

**PLAY:** Allows the player to select the level of the game and starts the game session. If the game session is successfully completed, the player may have two choices. The first choice is to continue with other themes in the same level and the second choice is to move to the next level.

**OPTION:** Allows the player to change and view the game options, for example:

**Score:** discover the last three best scores in the game.  
**Restart:** repeat a new experience.  
**Settings:** change the setting of game parameters like sound, language...

**About the game:** discover the rules of the game also see more information about the game.

**EXIT:** Allows the player to exit the game.

The figure below illustrates the main game menu interface.



Fig. 5. Game main menu interface proposed.

The figure below shows the interface of the first level «INITIAL BALANCE».

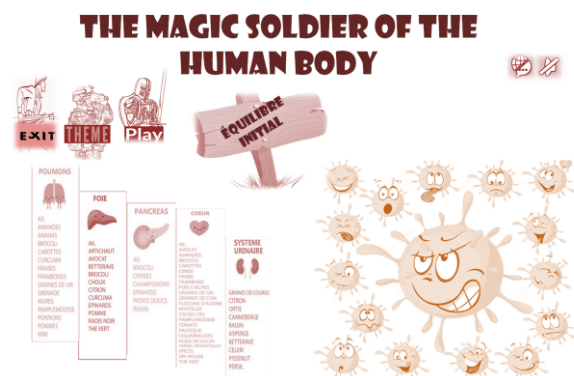


Fig. 6. Interface of the "INITIAL BALANCE " level of the proposed game.

In the level "INITIAL BALANCE", the player must select a theme among the four themes offered and started the game, for example, for the theme "basic nutritional needs",

the player must observe and memorize a list of foods needed for each family (organ of the human body). Then, after a period of a few seconds, the player must put in place the right foods for each organ. Indeed, the goal of this level of the game is to observe and memorize foods and deliver them to the appropriate family. If the food is successfully placed for the matching family, the coronavirus will have an emotion of sadness and the soldier improved his strength. For each food we have proposed coronavirus emotions and also castle soldiers. At the end, of the game the player will find out the strength level of the soldiers and also the general emotion of the coronavirus. The figure below shows an example interface for the topic "Basic nutritional needs".

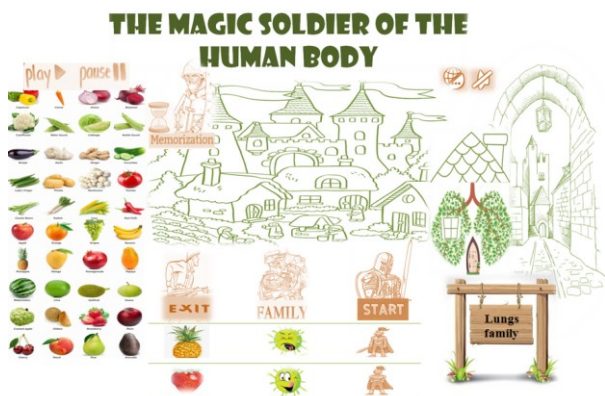


Fig. 7. Interface of the proposed "basic nutritional needs" theme.

### C. Motivational factor in the proposed game

In serious games, much more active learners have the opportunity to interact with information through certain motivators. According to Thomas Malone and Mark Lepper (1987), motivation in a learning context is intrinsic; therefore, engagement in a game is for the game and not for receiving an external reward [9]. Most theories on intrinsic motivation are inspired by the concept of flow state developed by Mihaly Csikszentmihalyi (1990). The concept of flow would represent the state of physical and mental immersion in which a person would be so engaged that nothing else around would matter. Table 5 below presents some motivational aspects that characterize our game.

TABLE 5: MOTIVATIONAL ASPECTS OF PLAY THE MAGIC SOLDIER OF THE HUMAN BODY.

Motivational factor	Description
Commitment and persistence	The nature of the learning environment and the quality of the interaction between the learner and this environment is to generate a growing interest in the activity during the game.
Feedbacks	The interactive and ludic learning environment (human body-castle) provides immediate feedback on each of the actions carried out
Guarantee a balanced connection between the ludic aspect and the serious aspect	The entry into the serious aspect to be done gradually in the game with amusements presented at certain moments of the game while keeping in parallel the serious content integrated in the mechanics of the game. Indeed the goal is to obtain the best ratio between the quality fun and educational efficiency.
Immersion in the game	The well structured game which provides a progression of skills through different stages to have a flow situation.

### D. Design of the proposed game

In order to facilitate the design of our game, that is to say to help achieve a balance between the fun aspect and the serious aspect, it is necessary to specify the design stages. We propose to perform an analysis of the game scenario by using a serious game analysis and design tool called "the six

facets of serious play" [10]. The facets of the design of serious games allow to analyze the design, They clarify at each step what must be designed and allow the stakeholders to identify the objectives and find their bearings in the design. One of the other advantages of the 6 facets of the design of serious games is to designate for each of them the most qualified type of experts for each aspect of the design, which allows each designer to situate himself in relation to this expertise. This method facilitates analysis in a structured and categorized manner. It identifies the key factors of the game without leaving out the essentials. Table 6 below presents the 6 facets of designing serious games.

TABLE 6: PRESENTATION OF THE 6 FACETS.

Facet	Description
Facet 1: educational goals	What do we want to teach the Learner-player? Definition of the domain reference and educational objectives, including misconceptions.
Facet 2: Domain simulation	How to respond to the learner-player's proposals? Definition of a formal model of the domain on which the simulation is based.
Facet 3: Interactions with simulation	How to give pleasure to the Learner-player by allowing him to formulate his proposals and receive the responses from the simulation? Definition of interactions with the formal model and therefore of the intrinsic metaphor
Facet 4: Problems and progression	What problems should the Learner-player solve? Definition of progression in serious game levels / missions
Facet 5: Decorum	By what script and multimedia elements provide pleasure to the Learner-player? Definition of "decorum"
Facet 6: Terms of use	How to exploit serious play while preserving its educational and playful qualities?

## V. COMPARATIVE ANALYSIS

In the previous sections, we presented the elements and the proposed game methodology. This section describes a comparative study of our game idea with other awareness games related to the Covid-19 theme and the human body through educational activities. This evaluation takes into consideration three axes:

Dimension of coherence between the playful aspect and the serious aspect;

Motivational aspects;

Commitment, immersion and quality of the gaming experience.

The first example is the "THE HUMAN BODY" application, developed by Tinybop Inc in 2015, presents the player with a progressive discovery of the human body. Players create their profiles. They can then select what interests them: the respiratory system, the olfactory system or the auditory system. In this environment, for example, the player passes through each organ. He watches the food coming into the stomach and breaking down; he pursues it in the small intestine and he sees the nutrients being absorbed; to finish by the large intestine where, the stools are evacuated. An activity "too serious" and a low ludic perception, which limits engagement, immersion and the quality of the experience. Indeed the motivational aspect is presented with low power, requires even more constraints that are ludic and motivating interactions. Then the second example is the «PROJECT REMEDIUM» where a nanobot is responsible for destroying the diseases that attack the body and also to treat fragile areas. The game likes to use the body image as a macrocosm. The used promotional image for

game communication plays the sci-fi card. The image sums up an inconsistency between the ludic aspect and the serious aspect (visibility of the robot, however, on a nanometric scale, microbial culture). Indeed, this type of tiring game requires a lot of mental effort. Finally, the third example is «CoronaQuest» which makes it possible to raise awareness of the respect of the actions barriers by young people in order to limit the spread of the epidemic for a return to class in a safe climate. This free online card game suitable for young people and back to school only, visuals not very aesthetic and very complicated to master at first. Table 7 below shows a comparison between our game idea and previous games.

TABLE 7: ADVANTAGES AND LIMITS OF THE FOUR GAMES.

Games	Properties	Limits
CORPS HUMAIN	Propose une approche simple à utiliser.	Very weak motivational aspects.
PROJECT REMEDIUM	Propose un cadre de jeu motivant.	Compliqué à jouer et incohérent entre aspect ludique et aspect sérieux.
CORONAQUEST	Based on a simple approach.	Suitable for young people and back to school only and complicated to play.
THE MAGIC SOLDIER OF THE HUMAN BODY	Uses a realistic look : The very original idea of the game Guarantees a balanced connection between the ludic aspect and the serious aspect. Easy to play following clear instructions.	Strategic skills are necessary for success and the player must have good reflexes to defeat enemies.

## VI. CONCLUSION

In this work, we tried to show an idea of a serious game with a fairly realistic aspect, serves as an interface to discover, educate and train players to adopt good eating habits to strengthen the immune system. Our fighting game uses the human body as the game universe and offers to fight "virus" enemies with a real army inside the "Immune system" body. The characteristics of our serious game are the following: the coherence between the ludic aspect and the serious aspect, the use of the specific motivators to the game in order to allow the player wishes to continue and have fun with the game (aspects of challenge, of control, fantasy and curiosity). The proposed scenario depends on the content of the game, its ergonomics and the educational scenario implemented. In addition, we have proposed an analysis of the game scenario using a serious game analysis and design tool called "the six facets of serious play".

## REFERENCES

- [1] MC Grant L, Geoghegan M, Arbyn The prevalence of symptoms in 24,410 adults infected by the novel coronavirus (SARS-CoV-2; COVID-19): A systematic review and meta-analysis of 148 studies from 9 countries.
- [2] Press release « Covid-19: concerns about its mutation » , published 25.05.2020 .
- [3] Pizzorno JE Jr, Murray Michael T (Ed). Textbook of Natural Medicine, Churchill Livingstone, États-Unis, 2006, p. 645-654.
- [4] Starnbach MN (Ed). The truth about your immune system; what you need to know, President and Fellows of Harvard College, États-Unis, 2004.
- [5] Conover E (2015) "Environment, more than genetics, shapes immune system ", American Association for the Advancement of Science ; Latest news, published January 15, 2015.
- [6] Basu S, Yoffe P, Hills N, Lustig RH, The relationship of sugar to population-level diabetes prevalence: an econometric analysis of repeated cross-sectional data *PLoS One*. 2013; **8**: e57873
- [7] Prensky M (2002). The motivation of game play. The real twenty-first century learning revolution. *On the Horizon*, 10(1), 5–11.
- [8] ROCHA, R., REGO, P. A., FARIA, B. M., REIS, L. P. ET MOREIRA, P. M. (2016). A web platform of serious games

forcognitive rehabilitation: architecture and usability study. In *New Advances in Information Systems and Technologies* (pp. 1085-1095). Springer, Cham.

- [9] Rieber, Smith et Noah 1998, p. 29-37
- [10] Marne B., Huynh-Kim-Bang B., Labat J.-M. « Articuler motivation et apprentissage grâce aux facettes du jeu sérieux ». In : Actes de la conférence EIAH 2011. Conférence EIAH 2011 (Environnements Informatiques pour l'Apprentissage Humain). Mons, Belgique : Université