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Corona: a threatened kingdom! The serious gamebook's logbook

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Abstract

The article's proposal is to present the development process of a digital gamebook, as well as its results, made in partnership with the Biology department from UESC - State University of Santa Cruz (Ilhéus, Bahia) and the Digital Games Engineering Course from PUC Minas (Belo Horizonte, Minas Gerais). The goal was to inform and raise awareness about the COVID-19 pandemic, especially among the youth. It was necessary to approach themes such as the forms of infection, vaccines and prevention in a playful and creative form, resulting in a Serious Game with a medieval theme that is set inside the human body. The gamebook, which is available for free, uses interactivity and choice-making to raise awareness about the consequences of misinformation in the context of a pandemic that, to this moment, has made more than 6.87 million victims, and to place the player in the position of an active agent during the learning experience.

Keywords: *Coronavirus Pandemic, Gamebook, Games Methodology, Health and Science*

1 Introduction

In the Information Era we currently live in, it has never been so hard to verify the truth in the numerous messages, texts and videos that we receive every day. This information often comes from people we cherish or sources that shape our social behavior that, a number of times, share data that is not scientifically approved. The misinformation ends up affecting people's habits and personal choices, something that made, and still makes, all the difference in the Coronavirus Pandemic. In view of this, arises a challenge of figuring a way to encourage the general public to exercise their critical sense and develop a better rational judgment to protect themselves from the threats of misinformation.

Through a partnership between UESC (Biology) and PUC Minas (Digital Games Engineering), our project aimed to create a gamebook novelized in the form of a modern fable, through the creation of anthropomorphic beings based on the white and red blood cell's role in our body, which, in this scenario, is represented by a kingdom under the attack of a powerful foreign enemy. We hypothesise that this could be a way to encourage, in a interesting and fun manner, the reading abilities and understanding of prevention good practices in the fight against a pandemic that has made more than 702 thousand victims in Brazil alone (SAÚDE, 2023). To be able to do that, an extensive academic revision about COVID-19 was condensed into a clipping. Both game design techniques and narrative tools were studied and summarized. Then, we collected visual and narrative references, developed the base plot, a moodboard and concept arts, using the scientific information as primary reference, ensuring the validity of the story as an educational tool. After that, we deepened the fictional universe, making plot ramifications, evolving characters and creating situations to represent the dilemmas from reality. At least, we developed a system that allows non-linear navigation through the adventure, programmed all the gamebook's mechanics, created illustrations and polished narratives and dialogues. The project culminated into an online gamebook that is available at the official PUC Minas and UESC websites. The game, in Portuguese, is accessible through the following link: `https://jogospuc.com.br/pesquisa/corona/index.html`.

2 State-of-the-Art and Related Works

2.1 Science and biology in the fight against the New Coronavirus Pandemic

The coronaviruses (CoV) are a large virus family (coronaviridae) that may cause a series of respiratory illnesses. These range from the common flu to more harmful diseases, like the Middle East respiratory syndrome (MERS-CoV), the severe acute respiratory syndrome (SARS-CoV-1) and, more recently, the COVID-19, caused by SARS-CoV-2. The first case of COVID-19 was reported worldwide in December 2019 in Wuhan, China, and, in Brazil, in February 26, 2020 in the city of São Paulo (OPAS, 2022). On 30 January 2020, the World Health Organization (WHO) declared the emergence of the novel coronavirus (2019-nCoV) a public health emergency of international concern (PHEIC). (WHO, 2020)

The coronaviruses are spherical enveloped viruses with a genome composed of a single-stranded RNA molecule. The envelope surrounding the nucleocapsid is formed by a lipid bilayer, in which the spike (S), membrane (M), and envelope (E) proteins are anchored, resembling a crown, hence its name (Helmy et al., 2020).

SARS-CoV-2 can be transmitted from one person to an-

other by a handshake (followed by the touching of eyes, nose, or mouth), cough, sneeze, or by respiratory droplets containing the virus. The infection by SARS-CoV-2 may vary from asymptomatic cases and light clinical symptoms to moderate, severe, and critical situations, requiring special attention to new developments that may alert to a worsening in the patient's clinical condition, requiring hospitalization. There is still no treatment for COVID-19 with scientifically proven effectiveness. However, more than 150 types of treatments are under investigation to help in the fight against the pandemic, such as antivirals, anti-inflammatory, cytokines blockers, antibodies, cellular therapies, and others. Prophylactic measures have been developed to avoid the exponential growth of COVID-19 infection cases, illness, and deaths. The use of masks, hand sanitation, and social distancing were the prophylactic non-pharmacological measures used immediately since the beginning of the pandemic. But the main weapon is, in fact, the vaccination process, one of the pillars in the strategy to combat the COVID- 19 virus (ANVISA, 2022).

A worldwide search for the vaccine was established intensively, since the start of the pandemic. The vaccines from AstraZeneca and Sinovac pharmaceuticals are being used in Brazil since the beginning of the National Vaccination Campaign against COVID-19, in 2021. Thus far, four vaccines of different sources were approved by ANVISA for use in the national territory: Coronavac (Butantan; inactive virus), Oxford (Fiocruz and AstraZeneca; recombinant adenovirus vector), Comirnaty (Pfizer; synthetic messenger RNA) and Janssen (Janssen-Cilag; adenovirus serotype vectors 26 - Ad26) (ANVISA, 2022) . To ensure the vaccine's efficiency against COVID-19, it was established the use of booster doses after some time, in accordance with the vaccine administered. Regardless of what technology was adopted, the vaccines have the same purpose: to stimulate the immune system to produce antibodies against the COVID-19 virus. The immunological response after vaccination creates a memory so that if the person is exposed to the virus, it will be recognized by the immune system, which will quickly take action, eliminating it before it causes the disease. Until 30th April 2023, more than 13,3 billions of COVID-19 vaccines doses had been administered over the world. (ONUBrasil, 2023)

On May 5th 2023, the WHO Director-General reported that, during the fifteenth meeting of the International Health Regulations(IHR) Emergency Committee regarding the coronavirus 2019 disease (COVID-19) pandemic, it was decided that COVID-19 is no longer a public health emergency of international concern. However, it does not mean COVID-19 is over as a health threat. In fact, is important to note the difference between a PHEIC and a pandemic. The first one is a technical definition and the strongest global alert the WHO can formally make. When it is declared, countries have a legal duty to respond quickly, and ending it may represent the end of international collaboration and financing. A pandemic, on the other hand, is a descriptive term that refers to a disease that spreads over multiple continents. (Ross, 2023; G1, 2023)

2.2 Serious games

Games can be divided into two major groups: The ones that are meant purely for entertainment (Entertainment Games) and the ones that tackle issues in a serious manner (Serious Games). Serious games must not be confused with "boring games" as every game needs to be fun, and it is consensus that people consider the element of fun in serious games as of great importance. They are, as defined by Michael and Chen, games that use the artistic aspect of the medium to deliver a message, teach a lesson, or promote an experience (Michael and Chen, 2005). Saying that a game is serious implies that it approaches topics with previous technical knowledge in a rhetorical sense and with goals beyond pure entertainment. Nick Iuppa and Terry Borst, on the other hand, use the term *Story-Driven Games*, something like *Directed Games* (an interesting word, considering that the focus of this type of game is not in being "sober", but in the message that is delivered in a rhetorical and directed fashion) (Iuppa and T.Borst, 2007). It is also important to highlight the use of entertainment games as Serious Games: For instance, a history teacher may use games like Civilization V (Firaxis Games, 2010). This practice is defined as *Cultural Pedagogy*. In other words, products that were not made for educational purposes but that end up being important bridges of communication with society (Andrade, 2014). Therefore, serious game is not really a game genre. It is, instead, a collection of genres and factors that uses digital games as a tool for teaching, research, training, medical treatment, and other "serious" applications.

2.3 Gamebook

Gamebooks are a type of book with a non-linear interactive story. As Guimarães et al. (2016) indicates, a gamebook is a hybrid medium that merges games and interactive narrative book in a way that it turns into an interactive experience. Using gaming elements, such as challenges, rules, feedback systems and rewards, it lets the player navigate through the narrative, changing it. In other words, it allows for different outcomes according to the choices the reader makes along the way. It is similar to a Role-Playing Game(RPG)/Adventure solo, but, in most cases, without needing additional separate tools (die, character sheet, cards, etc.) to be played. The story progresses only through the consequences of the choices that the reader makes (e.g., going to the right, page 20; going to the left, page 12; talking with someone, page 04; and so on). This level of agency leads to a bigger impact in how the story unfolds because it grants a sense of protagonism to the readers when making decisions.

It's interesting to emphasise that Bidarra et al. (2012) presents the three typical game elements that can be used in gamebooks for educational purposes, along with it's main devices and objectives:

- **Progression**, through point accumulation and the presence of levels to overcome, stimulates ways of visualizing success in the game;
- **Investment** uses appreciation for a work done, collaboration towards an objective, interesting challenges and a combination of diverse resources to encourage evolution;
- And the **narrative** aims to motivate the player through realization of multiple tasks, unexpected situations to

keep interest high, creation of a sequence of new information discovery and the need to defend situations already conquered.

Although displaying a modern dynamic, this is actually quite an old narrative technique; For instance, in the early 80s, here in Brazil, Ediouro, a Brazilian publisher, released a series of books in this genre entitled Choose Your Own Adventure (a Brazilian version of the American series, a seen on **Figure 1**) that proved to be quite popular (Montgomery, 1979).

Figure 1. Three volumes of the Brazilian version of the books Choose your own Adventure. From left to right, "The Cave of Time", "Journey Under the Sea" and "By balloon to the Sahara".

In the 80s, this type of book inspired even more complex narratives, like the series Fighting Fantasy by Steve Jackson and Ian Livingstone Jackson and Livingstone (1982). These, although simpler, were closer to RPG systems, with character sheets and combat instructions in the first pages that used dies. These are somewhat niche products among RPG players and are still sold in bookstores and specialized stores.

Although seen by some as a forgotten piece of nostalgia, these interactive books transitioned naturally into the 21st century, and can now benefit, as digital versions and as online experiences, from a vast array of resources offered by the medium, like savepoints, assisted progression systems, enhanced level design, character customization and even Artificial Intelligence (AI) that prompts the player's choices, as detailed in the following section.

3 Methodology

3.1 Pre-production: defining the medium

As explained before, a gamebook is a type of book that tells a story in a non-linear and interactive fashion. In other words, it allows for results according to the choices that the reader makes along the way. Even so, we wanted to imbue the story we were writing with "deeper consequences" that would be made available according to previous player's choices. We could, for instance, have conditional values in the choices in the form of ranges that can enable or not new branches, just like keys that unlock different possibilities. In the Gamebook, this "programming" happens in a hidden and self-computing form: all it takes is setting a variable and adding or deducting points when reaching certain parts of the story. In our particular game, we had a system that penalized the player, in a sense, for making choices not backed by scientific knowledge, leading to alternate endings that show the consequences of making a bad decision. For this task, we were able to easily alter these variables in HTLM5, PHP, and CSS through the Front End Twine `www.twinery.org`.

The selected target audience was comprised of young people, from 12 to 17 years old, and, for this reason, we opted for a narrative that balanced pictures and text. The language is simple and direct, avoiding complex words or long paragraphs. We also used humor as a way of constructing characters and keeping the attention of the player. In general, the text is also very descriptive, so the player can make decisions only with the given information and without relying too much on previous knowledge. We opted not to use plot twists as a narrative device, given that all the events in the game are basically the direct result of the player's actions.

3.2 Clipping

The partnership with the biology course from UESC mostly aimed to provide clear and accurate information on the pandemic as much as possible. Through this partnership, we compiled and updated (since new data on the virus was released all the time) as much information as possible to support the story. This procedure was not only done for the initial construction of the story: whenever something new was written there were multiple queries with UESC to validate the statements made in the game. This knowledge was compiled into a clipping, which is, according to Rabaça and Barbosa (1998),

> "a service of clearance, collection and sourcing of newspapers and journals clips about a certain subject, the activities of a certain company or institution, about a certain person, etc." (1998, p.138.)[1]

Teixeira (2001) indicates that a clipping is a tool to monitor information broadcast thought various mediums, condensing these materials in a single place. Therefore, it becomes a secondary source of information that has already been selected, categorized and summarized based in previously defined criteria, accordingly to each project and it's objective. Our clipping was constantly updated during the development of the project in response to the flow of new information on COVID-19. It's construction was based on the following thematic areas:

- **The recommendations on the mask usage** in the COVID-19 pandemic, aggravated by the lack of commercial supplies, led people to create several mask alternatives to reduce the probability of spreading the virus, but the majority of those were less or not effective at all. With the knowledge that the COVID-19 virus is transmitted by air, the use of a proper mask is essential.
- **Hand sanitation** is a prophylactic measure for COVID-19 virus transmission. One of the main forms of transmission occurs when there is virus contact with the eyes,

[1]Translated by the authors. Original quotation, in Portuguese, is "serviço de apuração, coleção e fornecimento de recortes de jornais e revistas sobre determinado assunto, sobre as atividades de uma empresa ou instituição, sobre determinada pessoa, etc"

nose, and mouth from not washing hands properly. So, keeping clean hands can avoid infection and virus transmission.

- **Social distancing** turned out to be really effective in reducing the advance of the COVID-19 pandemic and covers a series of measures to reduce the circulation of people in collective spaces, decreasing the spread of the virus and its transmission from one person to another.
- **Fake News** is known as a synonym for disinformation. One can define fake news as a component of narratives completely or partially false that have the intention of deceiving, creating illusory sensations or perceptions through its disclosure in social media with great potential for becoming viral.

The entire clipping, in Portuguese, can be accessed through the following address: `https://bit.ly/clippingbiogamebook`

3.3 Inspirations

The main sources of inspiration for the story were the Spanish comic *Dos Glóbulos en Apuros* and the Japanese anime Cells At Work!, both presented on **Figure 2**. Below is some information about these works:

- ***Dos Glóbulos en Apuros*** is a comic written by Daniel Regueiro and illustrated by Sanchez Muñoz. It tells how the human body works in a fun and colorful way littered with Pop Art influences. It was edited in 1979 and is the second number in the collection Great Adventures published by ESCO (International Center for School and Communication Studies) from UNESCO UNESCO (1979) The adventures of Pepe the Red and Tito the White show in a didactic way how the human body works, with a pleasant writing style that is accessible for all ages.
- **Cells At Work!** is an anime released in 2018 and available on Netflix. What if the human cells were people? In this world, red and white blood cells need to do their jobs in the midst of bacterial invasions NETFLIX (2018). Told in the characteristic style of Japanese animation, Cells at Work features battles against external enemies, decision-making based on collected information, and cooperation among the inhabitants of the "world". These aspects, together with the narrative style of *Dos Glóbulos en Apuros*, formed the backbone of our story.

Finally, on the decision of telling a modern fable: the fantastic and magical context allows us to represent concepts such as vaccines, in the form of potions that enhance a knight's strength, or the infection of cells by the virus, with the peasants being possessed by Coronas, making for a more interesting, didactic, and easier way to learn for the targeted audience, while also providing funny sections. As pointed out by Malone (1981), the use of intrinsic fantasy for the abilities required by the game, like reading (descriptions of scenarios and passages), interpretation (of the situation and the given data), and choice-making (analyzing the information and calculating possible outcomes), through the use of

Figure 2. On the left, the *Dos Glóbulos en Apuros* comic cover. On the right, a promotional art of Cells at Work!

metaphors and analogies, provides a more interesting, and often more effective, learning experience, since the players need to apply their previous knowledge when assimilating new information. Malone also points out that intrinsic fantasies often demonstrate how a skill can be used in real-world scenarios, and one of our objectives was for the player to understand the relation between the medieval world and the pandemic scenario in order to comprehend the necessity of relying on scientific data and making responsible choices to protect their own health.

3.4 Concepts

Takahashi and Andreo define Concept Art as a project development tool for the entertainment industry that allows the production to become more coherent by materializing concepts and representing them visually, setting the standards for the artistic and visual proposal that will be followed Takahashi and Andreo (2011). The first step of visual conceptualization consisted of the research for aesthetic and visual references, aiming to define the artistic style that would guide all graphic production.

Figure 3. Project's moodboard, synthesizing it's main characteristics: bright colors, flat style and simple shapes.

The result of this exploration was condensed in a moodboard, also known as a semantic panel, a design tool that, as pointed out by Gardner and McDonagh-Philip, represents a composition generated from color collages, textures, images, and material samples that work as a "starting point" to the process of brainstorming Garner and McDonagh-Philp (2001). From the moodboard, we set the main visual characteristics of the art that would be created: simple shapes that

are easy to read, reduced palettes with bright colors, and a flat painting style, as seen on **Figure 3**.

Since the whole story takes place in a human body allegory, the first structure that took form was the kingdom in which it would take place. Every visual element started as a quick draft that got gradually refined until it became the final art, as it's presented on **Figure 4**. Beyond the walls that form the outline of a body, the goal was for all structures to fulfill a narrative function that alluded to their biological function. As the course of the project's development went on, the kingdom gained more details that were reflected in the characters and situations created for the story. Therefore, it is possible to see in the final concept art the castle where the monarch lives, a representation of the cranium that shelters the brain and that has the highest tower, representing the nose. The Spinal River is the spine. In the region of the heart, there is a Distribution Center, where everything that is produced will be shared between the different parts of the kingdom. Around the lungs, there are houses, where the peasants live, and, in the liver, an organ of vital importance for iron metabolism Grotto (2010), we have the Arsenal.

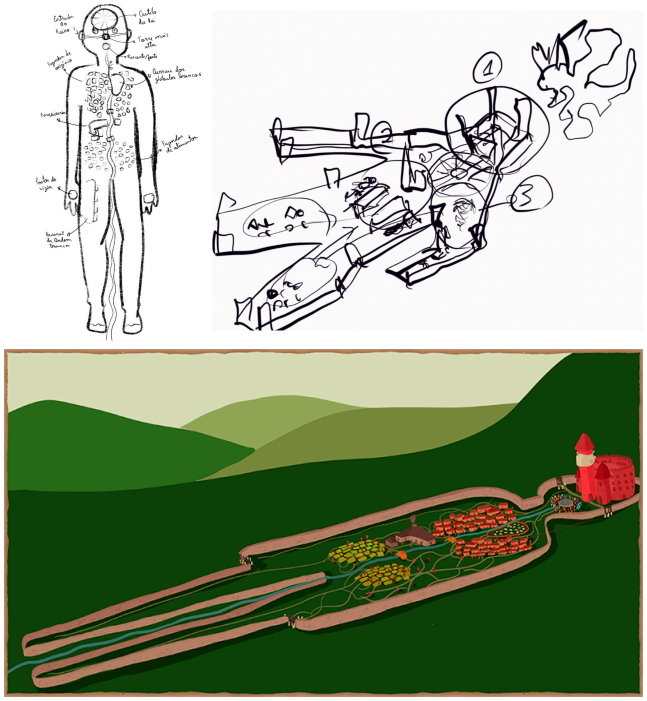

Figure 4. On top, the first drafts of the kingdom, a human body allegory. Below, the final concept art.

When starting the character development phase, it was necessary to list their main functions, and, thus, identify the design needs, respecting the definitions of the moodboard. In this process, it was defined that each character would have a palette with only three colors, and that they needed to be characters that could live within a fantastic medieval context. They also had to allude to the cells and the biological functions that they represented.

Since the story takes place inside the same body, one of the challenges to be overcome was how to guarantee that the characters would look similar enough to be part of a single larger body, and, at the same time, have unique designs that would allow differentiation and identification. After some experimentation, the answer to this problem seemed to be solved, mostly, by the nose. In other words, every character that represents cells from the same body shares the same nose, while outsiders have different shapes of noses, or don't even have one. The process resulted in the following characters, represented on **Figure 5**:

- **General T**, the Duke of Lymphs, is the commander of the White Order, the army of royal knights that represents the lymphocytes, cells that compose one of the natural mechanisms of defense in the human body against the aggression imposed by pathogens. Since the story is set in the context of an invasion, it was essential to have a character that would represent at least some part of the immune processes. The white clothing references the white blood cells, the popular name given to the defense cells of the body, and the armor symbolizes his function as a protector.
- **King Neuro** is the ruler, responsible for decision-making. In addition to being the anthropomorphized representation of the brain, he is also the playable main character in the gamebook. We decided that the player would take on this role in order to demonstrate that the rational decisions we make affect the way the body can deal with the consequences. The colors purple and yellow were chosen because they are related, respectively, to the concepts of royalty and wealth, and the reddish tone alludes to the color of the organ.
- **The Coronas** are the mystical representation of the coronavirus. Viruses do not have a classical cellular structure, nor metabolism in their encapsulated form, nor autonomy, meaning that they depend on other cells to survive. For these reasons, these biological entities are not considered living beings Prosdocimi and Farias (2021). Therefore, their nose as removed from their design, demonstrating that the invaders are very different from the inhabitants of the kingdom. Using crowns, inspired by the actual virus, Coronas have pointed teeth that not only match their accessory, but also represent the danger. The color green was chosen because it is often associated with diseases and nasal fluids, and the predominance of gray creates a strong contrast with the bright colors of the kingdom. Just like the virus infects the cells, Coronas can attack and "possess" villagers, causing them to turn gray and gain pointed teeth and small crowns, maintaining the overall appearance of a peasant, but acting as a Corona and increasing the transmission, representing the process by which the virus multiplies within the body.
- **The Globules** are merchants and travel through the kingdom transporting supplies in their carts. They are an allegory for red blood cells, responsible for gas exchange, and plasma, the liquid that makes up the blood and circulates essential nutrients. As those who transport oxygen through the body, they have proven to be relevant characters for the context, especially since a common symptom of the disease is difficulty in breathing and low oxygenation. The color red was chosen in reference to hemoglobin, the protein responsible for the

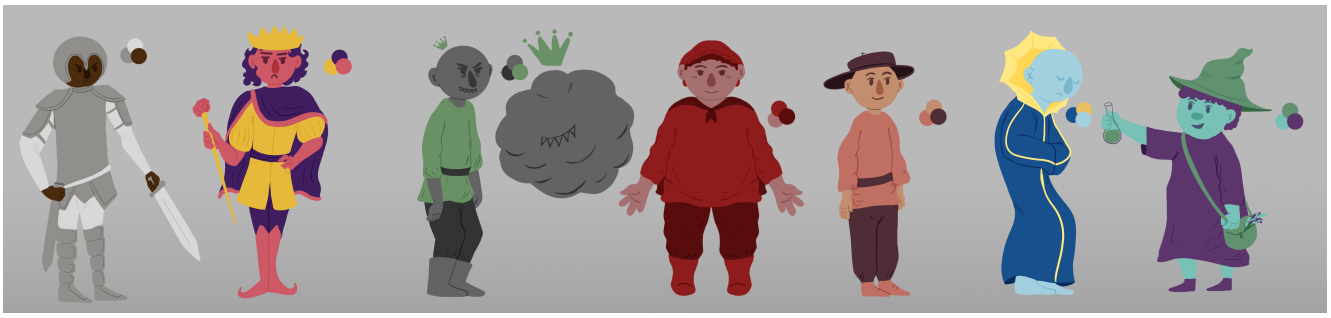

Figure 5. Final design of the project's main characters. From left to right: General T, King Neuro, Infected Villager, Corona, Globule, Helio Epithelium, Glia and Vinci.

reddish color of blood.

- **Helium Epithelium** a villager. Those represent the cells of the pulmonary epithelium, one of the organs most affected by the coronavirus. These characters role is to reflect the effects of contamination on the human body as a whole, and to be an allegory of society during the pandemic. After being possessed, some are completely overtaken by the virus and start to aggressively transmit it, while others are more resistant and may not even show symptoms. Throughout the text there are mentions of individuals who are on the brink of death due to lack of oxygen and require medical intervention, others with mild symptoms, some who recover completely, others who have sequelae, and even those who are negationists and suspicious. The player is invited, at different moments, to deal with these different situations and people, who may or may not agree with their decisions. The choice of predominantly beige and pink colors in their design aims to reflect the shades of a healthy lung.
- **The Glias** are the royal advisors, inspired by cells of the same name that have great relevance to brain function, such as protection and neurons nourishment. These characters provide information and advice to the King, which may or may not be correct and reliable. The shape of their collar mimics the biological form of these cells. The color blue was chosen as the predominant color to represent wisdom and calmness, essential characteristics for characters that are an important support to the player in decision-making, and yellow serves as a common element between the Glias and the King.
- **Alchemist Vinci** represents science. He is a friendly and helpful character, ready to answer any questions about his potions. We chose to use the figure of a researcher from another realm, who is a scholar, but may seem like a magician to those who are not familiar with his processes. Alchemists have the main objective of researching solutions to reduce the burden on the human body through science based on evidence. For the player, this character demystifies science and, throughout the story, serves as a trustworthy source of information, providing valuable advice on how to treat those infected, how to critically analyze doubtful information, and how to prevent the worsening of the Corona invasion. The color purple was chosen to represent magic and mysticism, as this is the impression a child has of science. However, the colors green and blue are predominant, representing, respectively, health and nursing (COFEN, 1999) and wisdom and biology (CFBio, 2009)

3.5 Game Production

Our project's backbone was to approach the subjects related to the COVID-19 Pandemic: good hygiene practices, vaccines, scientifically proven information, and other relevant themes. The project's storyline was clear: "Our kingdom (the human body) is under attack by a foreign enemy (the Coronavirus). We must prepare for incoming war by making important decisions based on scientific information." It is clear that the storyline, even if short, establishes guidelines and questions that we could work upon.

The initial proposal was that the story would be divided into three books, each with a focus on different characters, making use of the context, strengths, and weaknesses of each. The main themes were prevention, treatment, and fake news regarding the disease. At that point, we were exploring ideas in every direction, gathering references, crossing information in the clipping and making quick drafts, trying to figure out what scenarios were better to represent and how we could anthropomorphize the body functions into characters. Those ideas were usually written by hand in a process notebook, mostly in a very summarized way as possibilities, not decisions. Then, on our meetings with UESC, that happened about once every two weeks at this stage, we discussed which ideas seemed better, what where the most important points to address in each part an if the analogies made sense. **Figure 6** is a copy of one of the first pages of the process notebook, showing the defined main points to be approached and a lot of discarded ideas, as also some of the early stages of the decisions that made into the final product.

This initial stage of exploration and discussion with the team took a long time. After 3 meetings, as shown in **Figure 7**, a lot of changes and verifications, we had defined that the story would take place in a complete medieval setting, made the first daft of how the Coronas look and whats it's main strength - the ability to disguise itself turning "invisible" - and who were our main characters. Also, the three stories would be respectively through the eyes of General T, Helium Epithelium, and King Neuro, although they didn't have these names at the time.

But, after months of development, the research about an effective treatment for COVID - and not just for its symp-

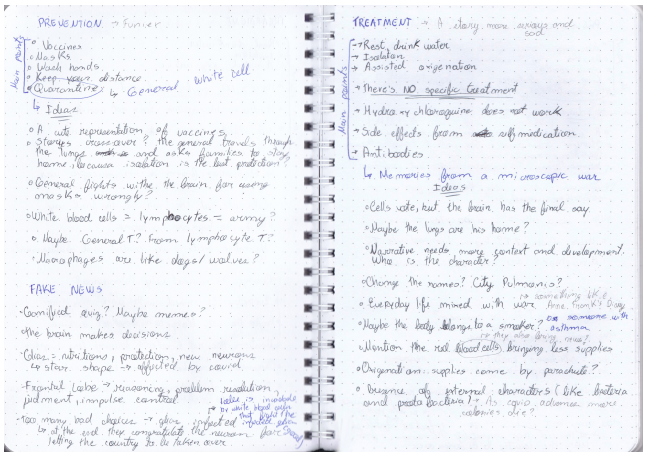

Figure 6. Early stage development ideas for the three gamebooks. It's possible to see, for example, on the prevention topic, that the army of white blood cells were thought of since the start.

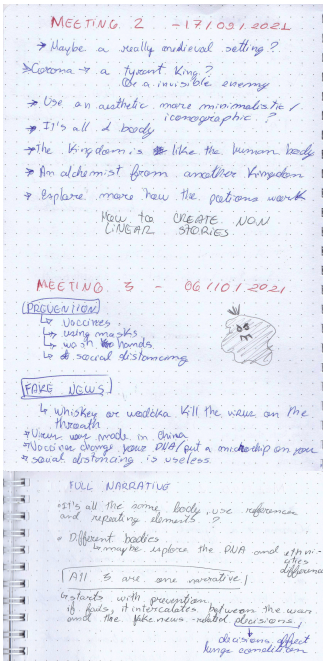

Figure 7. Brief annotations made during the meetings with the whole team. It's possible to see decisions that were set, an also the first draft of how a Corona looks like.

toms - had yet to produce significant advances. Besides that, the creation of a narrative surrounding only the fake news aspect proved to be a challenge. As such, it became necessary to alter the story's structure and the three books became one, told through the perspective of the same character, and divided into two parts: before the war, focused on prevention, and, after the war, with focus on the treatment of symptoms. The fake news aspect is tackled during both parts. After this change, we decided it was essential that the players felt that their choices were relevant through the narrative, and it was necessary to develop a way to show that the results from the first part had a direct influence on the second part.

The process of developing the choice tree started by creating a very simple prototype, in our case, hand drawn on paper, in which the scenes where the main points defined on the last step were addressed are disposed and briefly outlined. Then, we made some experimentations on how one scenario could lead to the other, what outcomes would the choices have, until we had a very simple skeleton of the game's structure, represented on **Figure 8**.

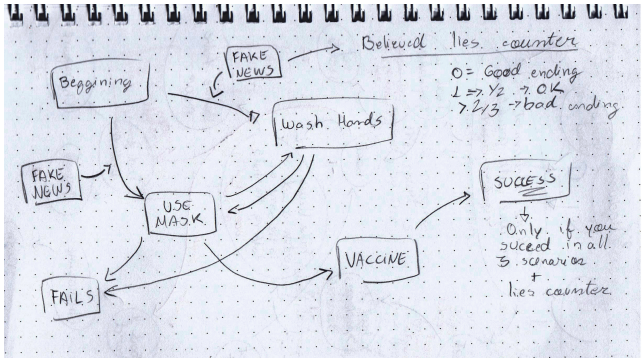

Figure 8. Early simplified draft of the narrative structure of the gamebook's fist part.

This prototype, then, was recreated into Twine, programming the logic and adding the necessary support scenes. When we started this phase, the code worked mostly as a "mechanical" tool, as instead of programming variables inside the same scene to support different situations and calculate the correct outcome, we simply duplicated scenes that needed to appear more than once during gameplay, or that had different outcomes depending on the order you went through the adventure. This led to a more complex web, shown on **Figure 9**, that was hard to adjust. Therefore, after the second prototype was approved, it was refactored and optimized.

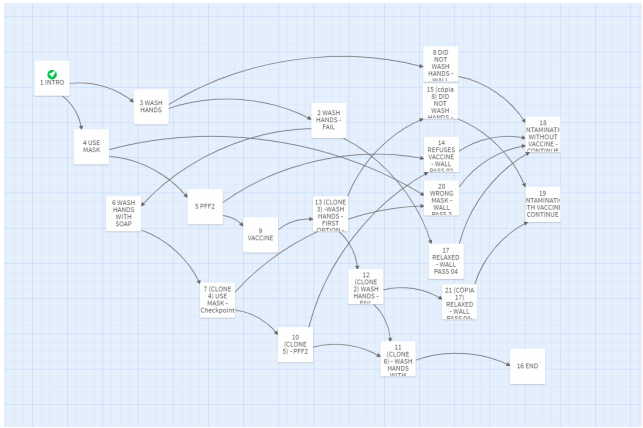

Figure 9. Digital prototype of the narrative structure of the gamebook's fist part.

With the prototype working, we focused our efforts on the final narrative. At this point, with concepts approved and the main plot ready, we wrote page by page, adding descriptions, dialogues, features and illustrations, until we had a finalized chapter, whose structure can be seen on **Figure 10**. Later in the project, we revised and optimized the chapter, refining the code and overcoming the need for duplicated pages. In the first part of the game, the branches progress from the decisions of whether to wear masks or not, what kind of mask to use, how to properly wash your hands, believing that drinking alcohol will eliminate the virus in your throat, encouraging to take the first and second shots of the vaccine, and

believing, or not, in the fake news that said that the vaccine will alter our DNA or put a microchip in our bodies.

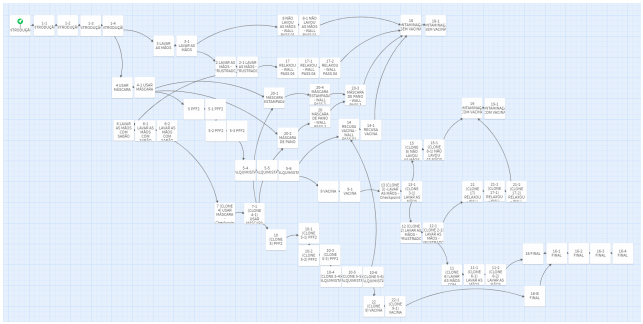

Figure 10. Page structure of the gamebook's fist part.

In each of these situations, there are usually three basic branches that the player can follow. One is scientifically correct, the other goes against scientific guidelines, and the last goes somewhere in-between, where the guidelines are followed, but not properly. Depending on the gravity of that choice, it could lead to failure, a chance to fix your mistakes, or success. The most relevant variable in this chapter is the one surrounding the vaccine: if the player accepts to take two shots, there will be a good ending; if they take only one, then they get a medium result. And, if they refuse to take even a single shot, they get a bad ending. It is worth pointing out that, to get the best possible outcome, the player not only needs to take all the shots, but also to protect themselves by using masks and washing their hands properly. Otherwise, they will be taken to a failure state which can have major or minor consequences, depending on the number of shots taken.

All relevant choices were programmed as variables to be tracked as a way to ensure, during implementation, the feeling of responsiveness to the player. The value 0 was used to indicate that a choice was yet to be made. Positive values indicated good decisions, and negative indicated bad ones. With this information, it was possible to generate pages that adapt to the result that the player obtained. Since the platform allows for the use of the conditional tool for every element, it was also possible to alter the pictures shown to the player based on the choices, an element that helps with the immersion, as represented on **Figure 11**.

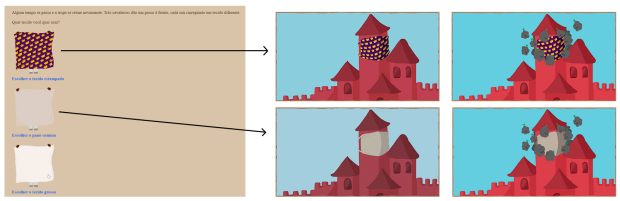

Figure 11. In this page, the player needs to choose a fabric to protect the highest tower, an allegory to choosing the correct mask. In all the next pages where the tower appears, the image shows the fabric the player chose.

Using conditionals that reveal specific texts depending on the value after the choice, it was possible to guarantee that the text responded exactly to the answers of each player, and pieces of text could be shown or hidden based on previous choices, as seen on **Figure 12**. That way, two different players could read a lot of information and have small details differ from each other. This process was especially relevant in the pages that concluded each chapter, where the game makes comments that directly reference the relevant choices taken during the playthrough and indicates whether they were ideal or not, reinforcing the good practices taught during the interactive experience.

```
-I can almost guarantee, sir, that your strategie was a sucess. The kingdom is safe! Even if the enemy keeps attacking, we won't be invaded. - He completes firmly.

You laught briefly. The Glias, shaking their heads in approval, look at you.

-I agree almost completly, General. Our strategies were great.
(if:$fakeNews >=1)[Well, apart from that time when we believed in that rumor... at least there were not harsh consequences from it.]

You sigh and look throught the window.

-But the Coronas won't give up. They will keep attacking until they manage to invade. The reports from the other kingdoms keep coming, and a lot of them are telling theses creatures are mutating. What we will carry on protecting ourselves and being vigilant. The Alchemists will continue to improve their potions, the Coronas will become weaker, and then, when they finally manage to enter our walls,defeating them will be easy. - You say.

-Let's celebrate our victory, for now! Tell everyone! In 4 days we will have a great feast, for all the kingdom!

[[(Continue)->GOOD ENDING 3]]
```

Figure 12. Code snippet from the game showing the use of conditions for text reveal. The text highlighted in yellow will only appear to the players that have believed in a fake news earlier in the gameplay.

With the first part completed, we started to work on the second chapter. This one presents a different challenge, as we decided that the ending attained in the first part will impact the difficulty of the path that the player will thread in the second part: easy, medium, or hard. The higher the difficulty, the harshest are the consequences suffered by the body. Again, we made several hand drawn simple prototypes on paper until we figured numbers and a logic that seemed to work thorough the whole chapter, presented on **Figure 13**.

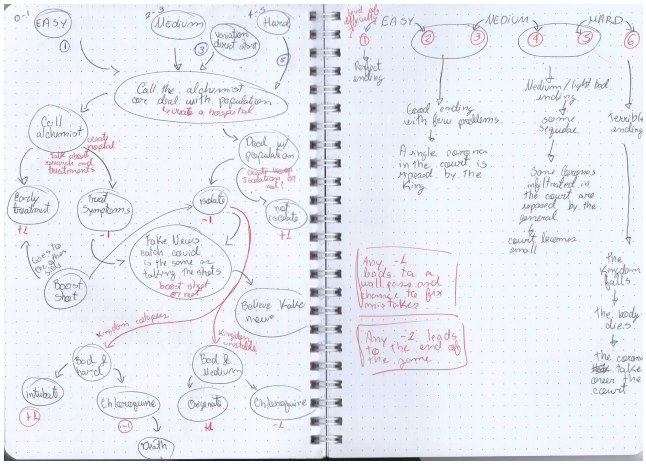

Figure 13. Early draft of the narrative structure of the gamebook's second part. This chapter was considerably more complicated than the first, as it had to adapt to the previous player's choices, witch reflects on it's size, even in the basic prototype.

In this chapter, the main choices revolve around treating the symptoms correctly. Using or not medicine that was

```
(if:$socialDistance is -1)[You see that part of the Corona army is
composed of possessed subjects. Following your orders, they kept working,
and were infected, one-by-one. While lots of them were converted to the
enemy side, many others lost the blattle for their own bodies.

With less people to take care of the kingdom,  the cattle and crops were
left unattended. The fields dried out, the animals are not cared for.
Even the castle is changed. Dust covers the furniture, there is mud all
over the place, and cracks are showing up in the walls.]
(if:$socialDistance  is 1)[

You see that a lot of houses are closed. You feel relieved, knowing that,
at least, some of your subjects will be safe. Certainly, the Corona army
would be bigger if you had not ordered your people to protect themselves
at the beggining of the war. ](if:$chloroquine  is 1)[

The joint medicine was useless. Not only it did not prevent the Coronas
from attacking, but it also left your subjects more vulnerable and less
wary of the enemy ](if:$oxigen is 0)[

You remember people having a hard time breathing. You cannot remeber if
they recovered from it or not. Filled with guilt, you think that you
should've listened to the nurses and taken better care of those patients'
needs.](if:$oxigen is 1)[

At the middle of the fight, you see one of the man that had trouble
breathing looking throught the infirmary's window. You are happy that he
woke up. He seems to have recovered well, and you are relieved that you
choose the best option for him. ](if:$fakeInfo is 1)[

Once again, you didn't listen to the Alchemist. Maybe the potion would be
an extra source of strenght to the fight against the Coronas. Perhaps,
this war could be easier.](if:$fakeInfo is -1)[

Litening to the Alchemist may have been your kingdom's salvation. The
fight is not exactly easy, but your knights appear to have a great
advantage. The potion really shows it's power, and seems to be the
difference preventing the kingdom's destruction. ](if:$sliceMedicine is 1)
[

The tea against lice only weakened your people. You remeber yourselve to
never believe in your subject's rumors again. ]

You watch, hopeful, as the number of Coronas decrease. Your army had some
losses, but after hours of battle, the last Corona is defeated!

You scream with joy!

[[(Continue)-> GOOD ENDING - MEDIUM 2]]
```

Figure 14. Code Snippet of the game showing each choice's feedback in one of the story's ending. All texts highlighted in yellow will only be shown to the player if they meet the condition specified. That way, results of the game are personalized, and address specifically that player's choices.

proven to be ineffective, advising the population to stay in isolation, taking the booster doses of the vaccine, believing or not that contracting the virus has the same immunization effect as the vaccine, and, depending on the active path, go or not through the process of invasive airway intubation. It is important to highlight that, to let players fix their mistakes but still ensure that decisions have consequences, the second part of the story is structured in a way where each choice changes the global difficulty level. For each decision, the difficulty is decreased by one if the choice was ideal, or increases if it was not. In other words, depending on the set of choices, it is possible to alter the level of difficulty of the game, mitigating or making the results worse. There are 7 relevant decisions, and it is possible for the player to go through all of them. That said, if players opt for two bad choices in a row, then the game will take them to one of the endings.

This way, the consequences are permanent, but there is still room for error and learning within a single playthrough. The set of decisions taken through the book will determine one ending within 6, that go from the perfect ending, in which the disease is easily controlled, and the body isn't left with any sequelae, only going through short-term or light consequences, to endings where the body is left with permanent marks and multiple organ failure. In the worst possible outcome, the body does not resist the infection. In the last pages for each of these chapters, each choice that the player was exposed to is revisited, as seen on **Figure 14**, ensuring that the reader can get some feedback on errors and successes.

3.6 Finalization and Release

Throughout the development process, there were several validation meetings. As presented before, during pre-production, their purpose was to approve character designs and the storyline, assuring that the analogies made sense and had a biological uphold. During production, we had a constant exchange of information between student project monitors to verify scientific data and align the game's vision. It's important to highlight that, for researchers outside of the biology area, the amount of information and specificity of technical terms regarding the human body, it's functions an cells, the COVID-19 and health in general can be overwhelming. If the project had not been done in a partnership, the chances of accidentally spreading misinformation would be bigger, as, even with attention, a lot of health data is presented in a way that expects the reader to have an extensive previous knowledge. On the other hand, the biology team, alone, would most likely not be able to create a gamebook as intricate and responsive, as it demanded a lot of coding and art production that relies on previous game development knowledge. In fact, the success and quality of the final project is due to the combined strength of two very different areas, where the team worked together as a whole. While each one has more property to talk about subjects related to their own area of knowledge, during all the development meetings everyone was encouraged to ask questions, suggest ideas, discuss the best ways to approach themes and solve problems. Game making is, inherently, a multidisciplinary activity and craft, and, in this project, it was clear that combining people from vastly different academic contexts has a lot of positive potential.

After the completion of the first version of the first chapter of the story, one of the most relevant evaluation meetings was held, during which the missing elements were listed, such as the mention of treatments for COVID-19 that are still under study, the disease's sequelae, the fact that the virus undergoes mutations, and the lack of efficacy of early treatments; the definition of the most relevant fake news to be explored; and the review and update of the topics that had already been addressed, such as the need for two doses of the vaccine and a booster one, why the vaccine development was so fast, and the reasons why social distancing is necessary. We also decided to make major story structure changes, an important stage for the final result reached.

With the game tested and approved, both from a game design and biology perspective, we finished the in-game assets. Then, we made the covers, both for the game as a whole (**Figure 15**) and the individual chapters, added music and wrote the credits page. The advantages of creating

a non-linear story via HTML5 are numerous, but, perhaps, the biggest one is that the format was born using hyperlinks natively and is part of the Web, not being dependent on any software, app store, or of technology that can easily become obsolete. All that is needed is a repository (web domain) in which to store the page online. And once a simple transfer of the final material via FTP is made, then the project is published to the whole world.

Figure 15. "Corona: A threatened kingdom" cover, presenting King Neuro and a Corona. Left button reads "Part 1 Before the War" and right button reads "Part 2 The War".

At the end, the gamebook consists of 62 original illustrations, 138 passages - also called pages -, and more than 18.600 words. **Figure 16** presents the full choice tree, with all the game's passages and theirs relations.

The next step for the research is the assessment of the educational effectiveness with the target audience. An evaluation form is in development and will be available, in Portuguese, at the end of the game, when possible. Our objective is to map the characteristics of the players, like age, gender, and education, and from that, analyze the perceptions of the groups that played the gamebook. Through the questions, we aim to understand which choice is perceived as the most difficult, if the characters' analogies are clear, and if the player learns about the coronavirus, the importance of vaccines, and the dangers of fake news. Of course, we also want to measure their perception of the gamebook as a game: if it is fun or not. In the future, we aim to publish another article focused solely on the analysis of young people's perception of the game, its effectiveness as a gamified educational tool, and its impact on understanding the scientific concepts involved in preventing and combating not only COVID-19, but also various respiratory diseases that can be avoided by maintaining good hygiene practices and caution.

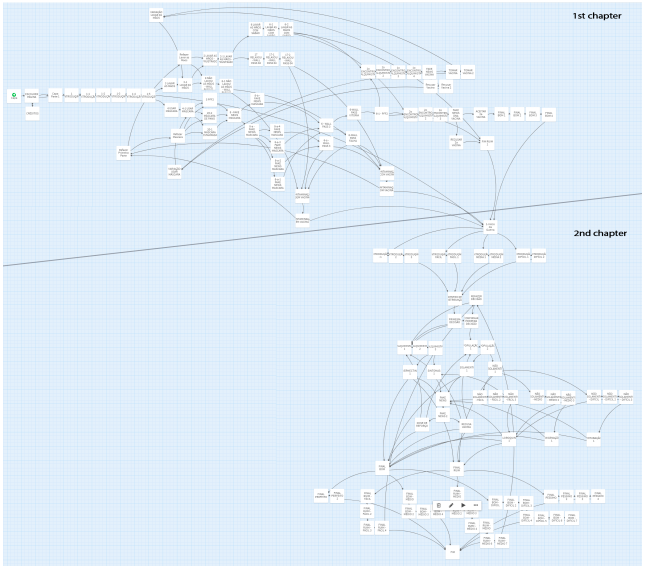

Figure 16. Gamebook's final choices flowchart.

4 Final Considerations

The purpose of this article is mainly to provide a production walkthrough and journal, so that others can seek information on how to produce a serious game project in the interesting virtual gamebook format, providing suggestions and examples on how the different phases of the process were developed. But, more than that, it is important to highlight the reach of critical reflection that can be incited by a project of this nature and with this theme made with the combined effort of two universities that are more than a thousand kilometers apart.

All who dedicate themselves to the craft of writing know, in principle, how to create stories. The word "narrative", so demeaned these days, reinforces the false idea that we can easily invert facts and distort reality, since we're equipped with good narrative rhetoric. However, in the Coronavirus Pandemic, it was never so important to strive for a speech that is based on science. On the other hand, the scientific discourse has found itself compelled to liquefy its language for a more general public, facing the challenge of not losing its informative essence, while also providing its historical and valuable service of safeguarding humanity, especially in matters of public health.

Fake news, dangerous and untrue information disguised as the "right or wrong side of the narrative," or even "freedom of choice/expression," have been abundantly cultivated during the first decades of our digital century, and gained a dangerous force in 2020, during the chaos generated by the uncertainties of a lethal pandemic. An equally interesting fiction and dichotomy was generated: the new century, full of technology, also brought the hope that it would be the season for countless evolutions, achieved by mature human beings that are able to tackle problems that had already been overcome in past centuries. Instead, we see the return of an almost medieval way of thinking, with the disbelief in science, the discredit of information, and the questioning of scientific institutions that produced them. A revisionism of historical and human health questions that we thought to have overcome. With this game, based on science and told in a (maybe not as

much) fictitious medieval world, we strived to reach a logical approach to the events and actions against COVID-19 in a playful way. As such, the game's purpose is not only to educate, but to provide a complex system that allows for critical reflection; after all, it is the player's choices that will determine the outcome of this "kingdom in danger". By creating an interactive non-linear system, we give the player-reader a place of protagonism in decision-making, which actively interferes with the story's ending. We enable a safe and online way of experiencing the consequence of our choices, without putting our bodies in danger, in the hope that this game can act as a form of ludic training to prevent future problems. Because the Coronavirus Pandemic is not over.

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References

Andrade, P. D. (2014). Cultura e pedagogia: a proliferação das pedagogias adjetivadas. [Online]. Retrieved from: http://xanpedsul.faed.udesc.br/arq_pdf/671-0.pdf. Accessed in June 16th, 2022.

ANVISA (2022). Agência nacional de vigilância sanitária. [Online]. Retrieved from: https://www.gov.br/anvisa/pt-br/assuntos/paf/coronavirus/vacinas/janssen. Accessed in May 30th, 2022.

Bidarra, J., Figueiredo, M., Valadas, S., and Vilhena, C. (2012). *Aprender na era digital: Jogos e Mobile-Learning*, chapter O gamebook como modelo pedagógico: Investigação e desenvolvimento de um protótipo para iPad. Santo Tirso: DeFacto Editores.

Carretta, M. L., Britto, A., Arrais, M., Moreira, R., and Bozzi, A. (2022). Corona: A threatened kingdom! a gamebook to combat misinformation. In *Companion Proceedings of the 21st Brazilian Symposium on Games and Digital Entertainment*, pages 1217–1226, Porto Alegre, RS, Brasil. SBC.

CFBio (2009). Resolução nº 187, de 27 de maio de 2009. Conselho Federal de Biologia. [Online]. Retrieved from: https://cfbio.gov.br/2009/05/29/resolucao-no-187-de-27-de-maio-de-2009/. Accessed in February 18th, 2023.

COFEN (1999). Resolução cofen-218/1999. Conselho Federal de Enfermagem. [Online]. Retrieved from: http://www.cofen.gov.br/resoluo-cofen-2181999_4264.html. Accessed in February 18th, 2023.

Firaxis Games (2010). Civilization v. https://civilization.com/civilization-5/.

G1 (2023). Covid: por que o fim da emergência global não significa o fim da pandemia. G1 Globo. [Online]. Retrieved from: https://g1.globo.com/saude/coronavirus/noticia/2023/05/05/covid-por-que-o-fim-da-emergencia-global-nao-significa-o-fim-da-pandemia.ghtml. Accessed in May 5th, 2023.

Garner, S. and McDonagh-Philp, D. (2001). Problem interpretation and resolution via visual stimuli: The use of 'mood boards' in design education. [Online]. Retrieved from: https://onlinelibrary.wiley.com/doi/abs/10.1111/1468-5949.00250. Accessed in June 13th, 2022.

Grotto, H. Z. W. (2010). Fisiologia e metabolismo do ferro. revista brasileira de hematologia e hemoterapia, 32(), 08–17. [Online]. Retrieved from: https://www.scielo.br/j/rbhh/a/DBW7X6wnFGpbLPmr6m63sGM/?lang=pt. Accessed in January 15th, 2023.

Guimarães, P., Tourinho, A., Vieira, J., and Alves, L. (2016). Uma análise das possíveis contribuições do gamebook guardiões da floresta para estimulação das funções executivas. In *Companion Proceedings of the 15th Brazilian Symposium on Games and Digital Entertainment*, pages 1165–1168, Porto Alegre, RS, Brasil. SBC.

Helmy, Y. et al. (2020). The covid-19 pandemic: A comprehensive review of taxonomy, genetics, epidemiology, diagnosis, treatment, and control. [Online]. Retrieved from: https://www.mdpi.com/2077-0383/9/4/1225. Accessed in July 30th, 2020.

Iuppa, N. and T.Borst (2007). *Story and Simulations for Serious Games: Tales from the Trenches.* Focal Press.

Jackson, S. and Livingstone, I. (1982). Books. [Online]. Retrieved from:https://www.fightingfantasy.com/home. Accessed in June 16th, 2022.

Malone, T. W. (1981). *Toward a theory of intrinsically motivating instruction.* Cognitive science, v. 5, n. 4, p. 333-369.

Michael, D. and Chen, S. (2005). *Serious Games: Games That Educate, Train, and Inform*. Cengage Learning PTR; 1st edition.

Montgomery, R. A. (1979). History. [Online]. Retrieved from:www.cyoa.com/pages/history-of-cyoa. Accessed in June 16th, 2022.

NETFLIX (2018). Cells at work! [Online]. Retrieved from: https://www.netflix.com/title/81028791. Accessed in August 12th, 2021.

ONUBrasil (2023). Chefe da organização mundial da saúde declara o fim da covid-19 como uma emergência de saúde global. Nações Unidas Brasil. [Online]. Retrieved from: https://brasil.un.org/pt-br/230307-chefe-da-organização-mundial-da-saúde-declara-o-fim-da-covid-19-como-uma-emergência-de-

saúde. Accessed in May 5th, 2023.

OPAS (2022). Organização pan-americana da saúde: Coronavírus. [Online]. Retrieved from: https://www.paho.org/pt/topicos/coronavirus. Accessed in May 30th, 2022.

Prosdocimi, F. and Farias, S. T. d. (2021). Vírus: reinterpretando a história natural e sua importância ecológica. pages 1791–1811. Revista Helius. [Online]. Retrieved from: https://helius.uvanet.br/index.php/helius/article/view/186. Accessed in December 16th, 2022.

Rabaça, C. A. and Barbosa, G. (1998). *Dicionário de comunicação*. São Paulo: Editora Atica.

Ross, E. (2023). What is the difference between a pandemic and a pheic? Chatam House. [Online]. Retrieved from: https://www.chathamhouse.org/2022/10/what-difference-between-pandemic-and-pheic. Accessed in May 5th, 2023.

SAÚDE, M. D. (2023). Coronavírus brasil. [Online]. Retrieved from:https://covid.saude.gov.br/. Accessed in May 10th, 2023.

Takahashi, P. K. and Andreo, M. C. (2011). Desenvolvimento de concept art para personagens. *SBC - Proceedings of SBGames 2011, Brasil.* [Online]. Retrieved from: http://www.sbgames.org/sbgames2011/proceedings/sbgames/papers/art/full/92122.pdf. Accessed in June 4th, 2022.

Teixeira, H. M. L. (2001). *O clipping de mídia impressa numa abordagem interdisciplinar sob os prismas da ciência da informação e da comunicação social; o ornal de recortes da Assembléia Legislativa de Minas Gerais*. PhD thesis, Escola de Ciência da Informação da UFMG.

UNESCO (1979). *Dos glóbulos en apuros.* Colección Grandes aventuras. J.M. Llorca, 1979.

WHO (2020). Statement on the second meeting of the international health regulations (2005) emergency committee regarding the outbreak of novel coronavirus (2019-ncov). World Health Organization. [Online]. Retrieved from: https://www.who.int/news/item/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov). Accessed in May 5th, 2023.