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Serious Game for Education and Training of Industrial Managers respect Pandemics

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Abstract

This paper is focusing in analyzing how the use of simulation and serious games could be effectively used to develop decision making capability within a crisis scenario; the authors propose here the simulation of a fictional scenario dealing with pandemics, where decisions should be finalized addressing multiple aspects considering multi target functions. The scenario has been used to conduct experimentations and to improve the impact on the training audience respect the covid-19 current crisis.

Keywords: Serious Games, Training & Education, Decision Making, Strategic Engineering, Pandemics

1. Introduction

Nowadays, the use of serious games is very popular for Education and Training, providing immersive opportunities for Virtual Experimentation where the trainees and students are engaged by some kind of edutainment (Charsky 2010; Jain 2011). Therefore considering the existing covid-19 crisis, it turns extremely interesting to use these solutions to support Institutions, Companies and Organizations into improving Safety and reducing Vulnerability to the pandemics. Due to these reasons, it was decided to create a series of Games for Managers in order to sensibilize over multiple issues, not only related to the pandemics, but also to a wide spectrum of management issues. Indeed, covid-19 crisis pointed out that most of the problems are not strictly related to the pandemics, but are dealing with structural problems of Institutions, Companies, Management as well as people mind set. Among these problems, for sure, major ones include Decision Making Capability, Responsibility & Authority Balance, Focus on real Achievements, Simplification of Processes and reduction of useless bureaucracy. In several European Countries, during covid it was observed the activation of regulations and protocols dealing with production of paper modules to be hand signed or additional recording just to reduce accountability of the responsible of specific procedures without taking care to reduce exposure and risks. In similar way, the capability to manage Strategic Communications over the different media channels was in most of European Nations a big failure and almost never applied the preventive planning existing since ½ a century related to epidemics and biological warfare, that were refined just recently considering the three major epidemics impacting the world on last 2 decades (Monto et al., 20020). In facts the reuse of available models respect pandemics could allow to easily and quickly support dynamically the creation of Serious Games (Avalle 1995,1996,1999; Bossomaier et al., 2009; Bruzzone et al., 2011). In addition, these models could interact also with models of economics and other layers.

2. Industrial Managers & Serious Games

So, it is evident that any crisis could impact on Companies and Institutions in similar way and require reorganization and mind set evolution to a more smart and effective management. In this sense, the Industrial Plants and Facilities are an interesting subject for these considerations; this is true in part because industrial working place are usually risky respect pandemics and often require in production physical presence of most of the workers. Therefore another important element to be considered that impact on industrial plants: education in dealing with time sensitive hard decisions, considering risks and evaluating crisis situation could have a big impact and it is much more feasible than in other contexts, considering the authority of production plant managers and their capability to reorganize their realities. In facts, the authors adapted different Serious Games for different purposes to be used in training and education for industrial managers, with special attention to industrial plant sectors such as it happen with IT Wets Game (XXXX).

In this paper it is proposed a specific game that addresses the issues of pandemics and teach the players how to adopt winning strategies even in hard conditions and how to finalize hard decision in time sensitive environment by understanding the situation evolution and readapting the planning. Indeed this represent a major service to support Strategic and Operational management under critical conditions.

3. The Game Framework

As anticipated the Game reproduce the pandemics crisis and each manager is required to play a crucial role, that one of a President of fictional Island State, indeed the game introduction is

"*You are the President. The man who alone can save Kvadrat's fate. The pandemic is upon us, and it threatens our country. But you will guide us in this dark time, and you will help us defeat this enemy as well!*

Glory to The President!!!"

The game is called "Virus&ThePresident" and it allows player to impersonate the figure of the president of Kvadrat, a happy island located in an unspecified place, during an epidemiological crisis. Through the player's choices, Kvadrat will have to survive for fifty turns corresponding to 15 months, until the cure for the disease is discovered.

When the authors started to develop the idea for a serious game regarding covid-19 situation, one of the first questions we asked ourselves was precisely to understand how to make a serious game, corresponding to answering the question how to make a game that could represent not only a form of entertainment, but also educational growth.

Although Virus&ThePresident is characterized by ironic components reminiscent of the gaffes and gossip of contemporary politics, the game relies on management mechanics that aim to simulate the spread of a new viral strain within a nation.

The raising of the infected, health measures, restrictions that can be used as a countermeasure, are all aspects that we have tried to represent using real data within a representative system.

The choice to represent an island state was not accidental: an island is characterized by a more closed habitat and more controllable limits. The type of political system used in the game is a popular dictatorship, or enlightened dictatorship, in the sense that popular consensus determines whether the leader can maintain power. Dynamics that we could define as 'hard', typical of a totalitarian regime, are therefore excluded. In this way, it was possible to transcend very complex dynamics concerning conflicts over decisions taken within a democratic parliament. In fact, as learned from Foreign Policy, a democracy seems to have more inertia in mobilizing resources than a more centralized structure.

The decisions of the leader/player are applied in the game, however, as we will explain later, this does not mean that they will be appreciated by the citizens of Kvadrat, who represent the essence of our power.

The type of economy we have chosen for Kvadrat is a liberal type based largely on the export of local products; this factor significantly affects the policies that can be undertaken, because they determine the resources that the dictator can invest. On the other hand, this also represents the external contact that Kvadrat has with the rest of the world, with the possible risks that may arise.

The pandemic introduces a disturbing element in this system, which we could define as stable. For the pandemic we have in fact decided to introduce destabilizing dynamics, which lead the system not to be sustainable without the use of targeted policies/decisions. For example, we might think that if a very large number of workers were sick, the Kvadrat industrial machine could stop, effectively causing an irreversible crisis within the state.

The state variables that represent our system, and which must be kept under control, are many, and they have all been chosen to reflect typical problems of particular situations such as the pandemic. Should one of these variables no longer be under the player's control, it is very likely that it exceeds the allowed limit and the game ends. However, not all variables are observable. As we will explain, the mood of the population is not a directly observable parameter. These variables are influenced by policies, which represent our input variables. All this will be aggravated by a limited amount of time between one round and another of the game. This will lead to greater anxiety and stress for the player, having to decide more things in a short time.

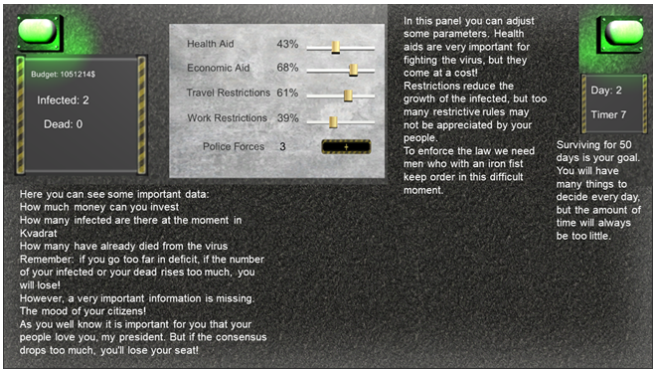

Figure 1. Games GUI

The game is therefore proposed as a managerial simulator, in which the leader will have to know how to manage within a problem characterized by the lack of truthful data and quick decisions to be taken.

4. The Game Mechanics

This logic of the game is summarized in the previous figure

Virus&ThePresident is a survival game of management mechanics: to win the game you have to survive for fifty days, days that represent the passage of time until the arrival of a cure for the disease. The management mechanics are based on a system of state equations, which manage state variables: budget, number of infected, number of deaths, mood of citizens. These variables must be maintained according to a balance in order not to exceed specific limit values, which correspond to the failure of the policies undertaken, and the end of the game.

To control these quantities, the player has input variables at his disposal, which correspond to the emergency policies that states all over the world use in order to limit the growth of the virus. These variables are described below:

- HA - Health Aids. The value of health aid corresponds to the amount of money the President decides to invest in public health each turn. This quantity is very important, since it changes several statistics within the system: the growth in the number of infected people (when the state decides to invest heavily in tampons, the population that will be infected will be automatically isolated and it would no longer represent a reason for the spread of the virus); the quantity of infected who heal per shift (more efficient hospitals allow better care for the sicks); amount of deaths caused by the virus per shift (similar to the previous point).
- WR - Work Restrictions. This value indicates the amount of work restrictions that the state decides to implement in order to limit the growth of the infected within the workplace. The quantity is expressed as a percentage, and with its growth the types of jobs that are forcibly closed as risky, as sensitive to contagion increase. This percentage summarizes the measures that Italy has also undertaken in its restrictions; we can imagine how initially the most sensitive work activities are closed with 10-20% of work restrictions; for example gyms and factories, then move on to restaurants, bars and so on. Obviously, the restrictions on the places where wealth is generated cause a lowering of economic growth for the state, the impoverishment of families with the consequent decline in the happiness of the latter towards the President.
- TR - Travel Restrictions. This value reflects decisions regarding the restriction of travel by citizens. This percentage also refers for example to the ban on walking in public parks, the ban on being with friends and relatives, up to the ban on moving between municipalities and perhaps the imposition of a curfew. These restrictions will have an impact on the morale of citizenship, but also on the economy itself, since many activities, such as tourism, would become impracticable.
- AE - Economic Aids. The value of economic aid represents the amount of financial aid that the leader can devote to financially support citizens. It is a parameter that symbolizes support for citizens most in need, such as those who have lost their jobs due to restriction policies. Obviously, the economic aid will have an impact on the available budget, but it will also have a positive effect on the happiness of the population. The use that can be made of it is that of balancing policies hostile to the population: a decrease in personal freedoms will be better accepted if accompanied by economic aid.
- PF - Police Forces. Law enforcement officers who can be recruited in the game. In fact, if the mood of the population drops too much, we have predicted that in addition to the growth of discontent, a form of non-respect for the restrictive policies adopted will develop. To tackle this problem, the police can guarantee the effectiveness of the rules adopted. Once recruited, it will no longer be possible to disengage them during this pandemic period.

The state variables are then presented with their equations related to the input variables mentioned above. Indeed the player should learn by playing how to correlate the scenario evolution with the general situation to develop his own understanding of the crisis as well as conceptual model to estimate the effect of his decisions

Budget

The budget represents the amount of money that can be invested in reforms during the game period. This parameter is representative, under normal conditions (without a pandemic), of a developing economy, and therefore is a growing parameter. With the arrival of the pandemic, behavior changes.

Depending on the policies that will be undertaken by the player, this growth can reverse into a decrease, leading to the accumulation of debt. The equation that governs this variable is below:

$$B(t) = B(t-1) + m(PL - PL_c - n\,WR - l\,TR) - p\,AE - b\,HA - z \cdot PF \quad (1)$$

Where:

B represents the budget value

m 0,1, size factor

n 1200, ratio factor corresponding to the loss of money linked to WR

l 800, ratio factor corresponding to the loss of money linked to TR

p 1300, ratio factor corresponding to the loss of money linked to AE

b 1300, ratio factor corresponding to the loss of money linked to HA

z 10000, cost of law enforcement units per shift

PL represents the population able to work (and therefore able to create added value),

PL_C workers who have been infected and are therefore unable to generate wealth.

If the Budget falls too shortly, set by us at 20% of the initial available Budget (-200,000 $), the game would end as a failure.

Infected

The growth of the infected is closely linked to the parameter R_0, that is the "basic reproduction number" which represents the average number of secondary infections produced by each infected individual in a completely susceptible population, that is, never came into contact with the new emerging pathogen. This parameter measures the potential transmissibility of an infectious disease. To combat it, the policies that can be adopted are restrictions, while it is possible to try to keep the infected under control with health aid.

The total growth rate including the implicit factors of the virus and the restrictive rules adopted, is described here:

$$u = R_0 - tt * WR * \frac{Sum}{100} - y * TR * \frac{Sum}{100} \quad (2)$$

$$Sum = H + 10 * PF \quad (3)$$

Where:

$R_0 = 2$

tt = 0,01, y = 0,01. They were chosen in this way considering the fact that if maximum restrictions were adopted for both WR and TR (total lockdown with impossibility of movement for all), the value of u would be null.

H is the amount of Happiness of our population.

Sum represents compliance with the rules, given by the sum of the trust of the population together with the presence of the police.

Figure 2. Virus evolution the Game

We describe with f the overall mortality rate, given:

$$f = g - v_1 * HA \quad (4)$$

Where:

g 0,023, death rate of the virus

v_1 0,0001, percentage of effectiveness of health aid

We therefore report the trend in the number of infected people per shift:

$$C(t) = C(t-1) + u \cdot C(t-1)\left(1 - \frac{HA}{100}\right) - v \cdot HA \cdot C(t-1) - f \cdot C(t-1) \quad (5)$$

Where:

$C(t-1) * \left(1 - \frac{HA}{100}\right)$ represents the number of infected that although the HA have not been identified as positive, and therefore can still represent a threat of infectivity.

v = 0,005, parameter concerning the effectiveness of treatment.

If the number of infected people exceeds half of the total population (500,000 people out of a population of 1M), the game would end due to the collapse of the health system.

Deaths

The number of deaths is related to the rate f described in the previous point.

We report the formula:

$$M(t) = M(t-1) + f * C(t-1) \quad (6)$$

If the death toll exceeds 175,000, the game will end.

Happiness

The policies that are adopted by leaders in the real world often do not represent a win-win condition, namely the fact that everyone is happy with such maneuvers. The reason we have studied in the course of Development Economy, and lies in the so-called Pareto laws.

These, in fact, are almost never possible to implement, since where there is a shift of resources to help a certain factor, it will cause a decrease in another. In our case, the reason for the conflict is represented on the one hand by our restrictive policies, which take something away from the population, and by the interests of citizens, which we have decided to represent with the Happiness variable.

In addition, the Mood parameter is not reported to the player. This is because it refers to a parameter that is difficult to quantify and that the policy cannot interpret correctly.

Not knowing this parameter, the player will have to rely on their intuition and visual mechanics that we will explain later. Here the formula reported:

$$H(t) = H(t-1) - q * TR - w * WR + r * EA \qquad (7)$$

Where:

q=0,3, factor corresponding to the decrease in happiness caused by TR

w =0,3, factor corresponding to the decrease in happiness caused by WR

r = 1, factor corresponding to the increase in happiness caused by EA

If the value of the mood falls below zero, the trust in the leader would be non-existent and the president would be deposed by the population, with the consequent loss of the game.

5. Media Mechanics

This section refers to previous figure, as we mentioned earlier, the Happiness value is not reported as a player observable parameter. However, there are several ways within the game to tell when the loyalty of the Kvadrat population begins to falter.

A first method of feedback is certainly given by the news of the newspaper that will be placed on our desk every day. As in real life, the media hold an important position in the dissemination of news, and also in Virus&ThePresident the media component is very important. These titles often give news regarding the mood of the population, reporting information that may be useful for the player to understand whether the choices made are pleasing to the citizens or not. However, the headlines will not always be important for the player: fake news and useless media headlines are unfortunately everyday life. The player must be able to recognize the important information (useful for rebalancing their maneuvers), from the useless ones.

The lights in the corners of the control panel can vary between colors: green, yellow and red. These represent a type of generic feedback, in the sense that they report the worsening of the status variables to the player: if, for example, the mood or the number of infected are dangerously approaching the limit, the lights will change from yellow to red.

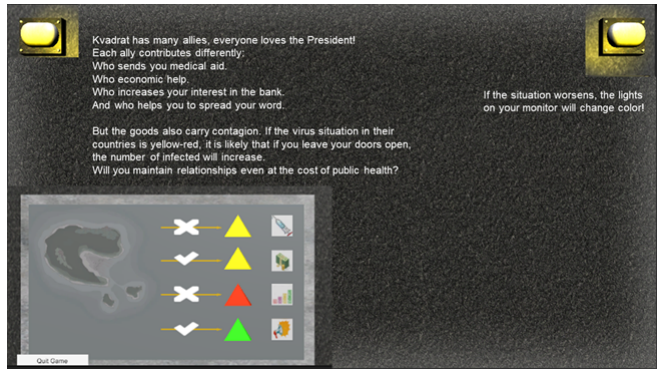

Figure 3. Situation Report within the Game

Linked to the mechanics of representing the behavior of the media, there is the possibility of controlling some information. Some news may in fact be harmful to the figure of the president, who may decide to keep them hidden. The control of information by the power is a well-known topic, addressed several times within our courses.

In particular, in the course of Foreign Policy we have had clear examples of how people in power have influenced the information intended for their citizens to gain political advantage.

From time to time, uncomfortable news will be proposed for the President.

This news is associated with a decline in the happiness of the population, and therefore it will be possible to decide whether they can be destined for the media.

If you decide to let them pass, there will be an immediate decline in Happiness; while if you decide to boycott the news, it is not forwarded to the media, but there is still a possibility equivalent to a third that the news filters and reaches the general public. In this unfortunate case, the decrease in Happiness would be double the original value. In fact, the population would understand that the President tried to hide uncomfortable news, and would perceive the scandal in a worse way.

6. Export Mechanics

This section refers to previous message and considers the exports; indeed, finally, we implemented the mechanics regarding Kvadrat's economic and political relations with neighboring countries. This is to represent the importance of commercial exchanges within the economy of this country.

In the game we have the possibility of being able to maintain or interrupt relations with the four nations allied to us.

These relationships will bring us great benefits: the contributions will concern an increase in health aid (sending medical devices and machinery), economic aid (sending humanitarian support), economic-

financial (which increases our amount of funds available), moral (symbolizing relations with a country that supports our cause).

Compared to equations (1), (7), along with EA and HA parameters, the contribution will cover an increase of 10% if the reports are ongoing (for example, if I keep open the relation that gives me more Budget (1), the amount of money will be increased by 10% in the next turn). Of course, keeping relations open with these countries is profitable in increasing the resources available, but keeping your country's borders open can be a threat during a pandemic. In fact, every allied country could infect part of our citizens during commercial exchanges.

This depends on the state of emergency in which that specific country is located. In fact, the countries will change color according to the amount of infected people who are there. Green indicates a minimal risk, yellow a moderate risk and red a high risk. The change of state of countries is calculated with a probabilistic function.

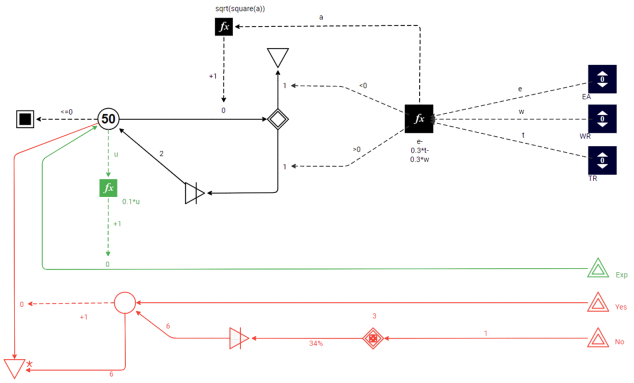

Figure 4. Machination Logic

7. Machination

We now present the machination concerning the equation of the Happiness variable for the game population. The total system would have been composed of the equations of the other state variables, but for simplicity and clarity in the presentation, we have chosen to represent only this one, as the others have a similar functioning.

The three colors represent the three different mechanics which refer to the same variable contained in the Pool of Happiness.

The black represents the mechanics linked to the three input variables: Economic Aids, Work Restrictions and Travel Restrictions. This represents the function (7), which will determine the increase or decrease in Happiness based on how we set our variables. In order to start the function once the variables have been set, it will be necessary to press the central Gate, to show the shift.

The green represents export dynamics: if the relationship with a particular country remains open, we will benefit from the aid it will send us. In this case we will have a plus 10% morale. The activation Source represents the opening or not of the relationships.

The red indicates the mechanics regarding the information that is passed to the President. We have two possibilities:

- If the President decides to pass the news, we will have an immediate penalty. This is represented by the Source Button (Yes).
- If the president decides not to spread the news, we will still have a one in three chance that the scandal will reach the general public. In this case the penalty will be double compared to the previous case. This is activated by the Source Button (No).

8. Conclusions

Even using basic functionalities of Unity it was possible to create a valuable representation tool for simulation models. In fact, our game is based on a virus simulation model on which we have applied other mechanics in order to make the game more interactive. Through Unity we have also implemented features based on irony, in order to make the game more engaging.

To understand if the game we were making had the specific requirements, we began administering alpha-tests of our game to acquaintances and colleagues. The feedback received helped us to make the game more balanced and to understand whether this product can be considered a serious game or not. The positive feedback and the examples of games that are offered in the training courses for executives (Dungeon and Dragons is often proposed as an example of collaboration) tell us that beyond the irony present in the game, this product can also represent a possible form of training.

Of course, a more accurate future study would certainly be of great help to be able to create an even more realistic model. In fact, through a multidisciplinary team, it would be possible to make a deeper study of how the variables relate to each other. Few of our variables are derived from scientific studies, while the others have been set up to make the game as balanced as possible.

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