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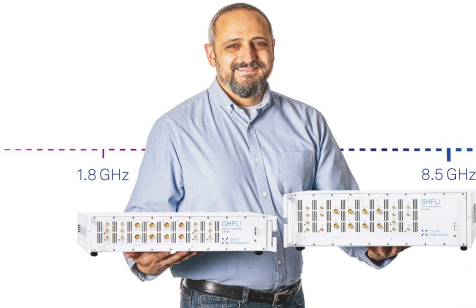
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# Plague Inc. Game in Teaching Future Geography and Biology Teachers

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**Abstract.** The game Plague Inc., known for many years, has experienced a rapid surge in popularity against the background of the spread of the COVID-19. This article describes the results of an experiment using the game Plague Inc. in teaching students (future teachers of geography and biology). During the study, three control groups of students (future teachers of geography and biology, future teachers of mathematics, physics and computer science and future bioecologists (non-pedagogical specialty)) were identified to compare the data obtained and to find out whether there is a correlation between the students' future profession, the successful completion of game levels and the assessment of its realism. The results showed that the implementation of the concept of edutainment in the learning process increases the level of motivation (makes learning more attractive for the students), provides easier and faster assimilation of the material, develops interdisciplinary connections, promotes the expansion of erudition and encourages to learn more about the studied topic, but at the same time and makes new demands on the teacher. In modern conditions, he must be deeper immersed in digital technologies and the gaming industry in order to be able to adequately select the necessary tools for his professional activity. Together with tracking modern trends, this will allow him not to lose touch with the younger generation, which contributes to a better understanding of each other, and, accordingly, easier communication. Despite the obvious successes over the past decade, further and deeper integration of gamification and edutainment into the educational process is required.

## INTRODUCTION

The development of the video game industry has started a few decades ago but is still not fully integrated into the educational process. It would be a mistake not to use such a dynamically developing field of education, in particular in teaching geography and biology. Changes in the world around us, as well as changes in the students' worldview, challenge the modern system of education and require new and adequate teaching methods. One of these methods is the active implementation of games in the educational process (gamification), which allows quickly respond to new factors that appear in the global informational space (a surge of interest in the game Plague Inc. against the backdrop of the COVID-19 pandemic) and make learning much more effective, interactive and interesting both from the student's position and from the teacher's position.

The COVID-19 pandemic has exacerbated and created many problems in our society. In particular, the world had to urgently go to the self-isolation and forcefully develop distance technology. This circumstance has both positive and negative sides. We are more interested in the fact that the pandemic began to contribute to the accelerated development of the use of VR technology in education and the gamification of the educational process. Both of these vectors are capable of reanimating the largely exhausted system of traditional education and many new methods,

which, despite their seeming promise, turn out to be extremely ineffective and even capable of leading to a drop in the level of education.

One of the first who combined these two vectors was Charles Coomber from California, who gave a math lesson using the “Half-Life: Alyx” game environment, right in the midst of a pandemic [1]. As we can see from this example, in order to introduce gamification into education, it is not always necessary to develop special games that will almost in every case lose to serious commercial entertainment projects.

There are some articles describing the benefits of incorporation of video games into traditional educational environments (gamification, edutainment) — about current trends and developments [2], motivational effects [3], various theoretical aspects [4,5], literature reviews of such studies [6,7], VR and gamification [8] and even about negative effects of gamification [9].

Despite the more and more active use of edutainment in the educational process, most of the teachers are wary of using game resources that were not originally created for educational purposes. Meanwhile, the most of special educational games are primitive and boring, since their creation did not take as much time and efforts as commercial projects. We believe that the use of such “professional” games is much more effective in the study of a wide range of disciplines and will be very popular.

The pandemic has also drawn additional attention to the game Plague Inc. [10], developed by Ndemic Creations in 2012 (London, England) in “disease ‘em up” genre, which is available for Android, iOS, Xbox, PlayStation and also for PC. At present, the number of downloads from the Google Play has exceeded 100 million. At the same time, the game attracted the attention of a wide audience long before the pandemic. In a sense, this is a realistic infectious disease outbreak simulator that already has become a part of the pandemic culture. Many observers have noted its “viral realism”, “scientific accuracy” and also the game is taking into account the power imbalances of our globalized world [11].

In general, we believe that people who were interested in the pandemic culture and had experience playing Plague Inc., accepted much easier the so-called “new normal”, as they were ready for it. They were prepared for such events not only by games, but also by other elements of mass culture — books (including speculative fiction), films (28 Days Later (2002), 28 Weeks Later (2007), World War Z (2013), etc.), and so on.

Plague Inc. is characterized by a high degree of immersiveness, so it can blur the edge between the real and the imagined. This game will be interesting both for hardcore (experienced) and casual gamers.

Other authors [12] have showed in their work the real use of such games as it is able to demonstrate the anatomy of the outbreak and act as a peculiar experimental laboratory. There are almost no articles devoted to the real use of Plague Inc. in learning [13]. There are known cases of using this game in the classroom in North America, but the results of this experience are unknown.

Nonetheless, Plague Inc. can educate the people in different ways. The representative of the CDC (Centers for Disease Control and Prevention) said that everyone can learn from this game about the spread of the viruses [11, 14, 15].

The final purpose of the game is to wipe out the entire humanity. First of all, the player has to select a country of origin of the pathogen (choose location of patient zero). Most of the game time the player is monitoring the world contamination map (geography of disease) — a rendering of the Mercator projection map of the world. During the process it is necessary to watch the spreading of the disease all over the globe (“cool zones” and “hot zones”) and various indicators on the scale of diseaseability. An interesting feature is that most of the victorious strategies start from China or from India (if you start from China, then you have a better chance of success). This can be explained by the high population, the presence of a large number of land borders, active passenger and cargo traffic, as well as a favorable climate. This game will be useful and interesting for biologists (due to the connections to the medicine, bacteriology, virology, anatomy, physiology etc.) and may be more interesting for geographers because it helps to understand the essence of the world (the differences between Global North and South, First World, Third World and so on). The player has to choose his own strategy based on his knowledge of the structure and problems of the real world.

During the gameplay the player sees several in-game messages notifying about how the custom pathogen compares to the real world outbreaks and pandemics. This game has a wide range of tools to make a pathogenic calibration. You have to evolve your pathogen in 3 different features: symptoms, transmission, and abilities depending on the events that take place in the game world — the response of governments of different countries to the spread of infection, research activities, military actions, quarantines, the elimination of sick animals or people, environmental conditions (climate, type of natural communities, possible ways of distribution — airborne, waterborne, etc.), demography (population density, concentration of rural and urban population, etc.), standard of living, and so on.

The purpose of this study is to find out whether there is a correlation between the students' future profession (teachers of geography and biology), the successful completion of game levels and the assessment of its realism.

Our research should answer the following questions: “Can we use entertaining technologies (games) while teaching geography and biology of schoolchildren and students?”; “How many students will want and be able to use similar games in their future professional activities as an educational tool?” and “How high is the level of training of students — do they have the necessary knowledge in the field of anatomy, physiology, medicine, bacteriology, virology, epidemiology, geography, etc.?”.

## METHODS

This research work has started in March 2020, at the very beginning of the COVID-19 pandemic, and has been finished in March 2021. The participants of the experiment were the students of the Institute of Natural Sciences and Professional Education of the Shukshin Altai State Humanities Pedagogical University. For this study we used the game application “Plague Inc.” (made by Ndemic Creations) which students downloaded from the Google Play or the App Store (the PC (console) version of the game was not used) (Fig. 1).



FIGURE 1. The game “Plague Inc.”.

This game suggests custom scenarios to develop 7 different types of pathogen (bacteria, virus, fungus, parasite, prion, nano-virus and bio-weapon) (Fig. 2). We asked the students to play this game (each had 3 attempts) in normal level of difficulty (there are 3 of them altogether: casual, normal and brutal). Students were free to choose a name for the pathogen.



FIGURE 2. The game's menu.

The distinctive feature of this game is the developed mechanism for constructing a set of pathogen traits and abilities. For example, you can evolve the various types of the transmission of the disease (spread of infection through birds, rodents, insects, livestock, blood-to-blood contact, air, and water), symptoms affecting all human organ systems and abilities (cold resistance, heat resistance, drug resistance and one special ability for every type of pathogen). Developing a particular set of traits, you determine the main characteristics of the disease — infectivity, severity and lethality (Fig. 3).

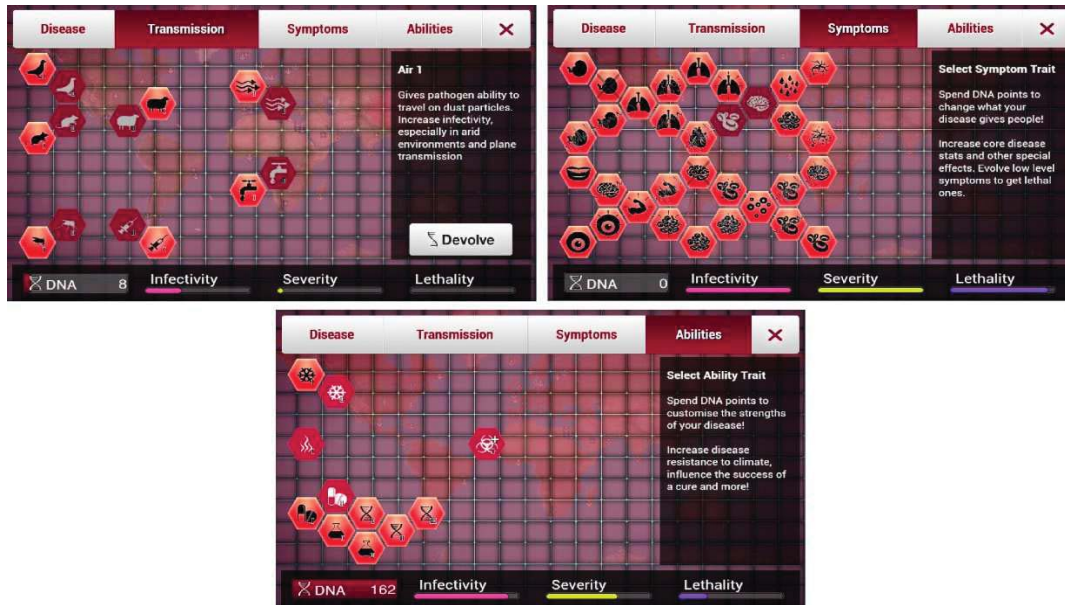


FIGURE 3. The abilities of the disease.

This explanation makes obvious that success in the game depends on what strategy player chooses. It is necessary to infect all the people in the world and then raise the level of lethality and eventually eradicate them all. The situation is complicated by the fact that as soon as the pathogen manifests itself, WHO (the World Health Organization) will begin to develop a cure. The knowledge of geography (climate (temperature, humidity etc.) of different regions of the world map, poor or wealthy country (it determines the level of development of medicine), main sectors of the economy) and biology (cognition of features of one or another type of pathogen, human anatomy and physiology to evolve certain symptoms) according to our assumption is an important advantage (Fig. 4).



FIGURE 4. World map in “Plague Inc.” showing the spread of infection on the planet.

To confirm our assumption, during this study we formed 3 control groups to compare their results afterwards. The first group included the teams of students studying to be *teachers of geography and biology* (they have a deeper knowledge of geography than biology). The second group included future *teachers of mathematics, physics and computer science* (they have lack of knowledge of geography or biology, but better training in logics and computer science). The third group was special because it consisted of students of *bioecologists* (non-pedagogical specialty), who had to have a higher level of training in biology.

After the game we asked the students to answer the 5 questions:

1. “What disciplines were the most useful for you to win this game?”;
2. “What was the hardest for you in the game?”;
3. “What knowledge did you lack to win the game?”;
4. “How do you rate the possibility of such scenario in the real world?”;
5. “Will you use this game in your future professional activities?”.

## RESULTS AND DISCUSSION

Table 1 shows the time that students of different groups spent on completing the game.

**TABLE 1.** Time of playing attempts of students of different specialities.

| Students                                         | Time of the attempt |                  |                  |              |           |              |           |
|--------------------------------------------------|---------------------|------------------|------------------|--------------|-----------|--------------|-----------|
|                                                  | Average time        |                  |                  | Best time    |           | Worst time   |           |
|                                                  | Successful attempt  | For bacteria     | For virus        | For bacteria | For virus | For bacteria | For virus |
| Teachers of geography and biology                | 39 min<br>43 sec    | 43 min<br>37 sec | 34 min<br>50 sec | 31 min       | 27 min    | 73 min       | 43 min    |
| Teachers of physics, mathematics and informatics | 28 min<br>30 sec    | 30 min<br>12 sec | 27 min<br>50 sec | 24 min       | 22 min    | 37 min       | 35 min    |
| Bioecologists                                    | 26 min<br>15 sec    | 28 min<br>17 sec | 24 min<br>12 sec | 23 min       | 21 min    | 30 min       | 28 min    |

Not all students who took part in the study were able to successfully complete both of the proposed levels of the game. As we can see from Table 2, the most successful students were, as expected, bioecology students, the vast majority of whom won the game for bacteria and over 60% were able to pass the second level. The worst results were shown by representatives of the second group — only 37.5% of students were able to win. However, all of them were able to pass the second level, while the future teachers of geography and biology showed good results during the game as a bacterium, but at the same time they looked worse in the game as a virus. The future teachers of mathematics, physics and informatics also quickly enough (faster than the first group) completed the task and only slightly lagged behind bioecologists.

**TABLE 2.** Time of playing attempts of students of different specialities.

| Students                                         | The quantity of students (%) who completed the game for |       |                    |
|--------------------------------------------------|---------------------------------------------------------|-------|--------------------|
|                                                  | Bacteria                                                | Virus | Bacteria and virus |
| Teachers of geography and biology                | 62.5                                                    | 31.3  | 31.3               |
| Teachers of physics, mathematics and informatics | 37.5                                                    | 37.5  | 37.5               |
| Bioecologists                                    | 81.3                                                    | 62.5  | 62.5               |

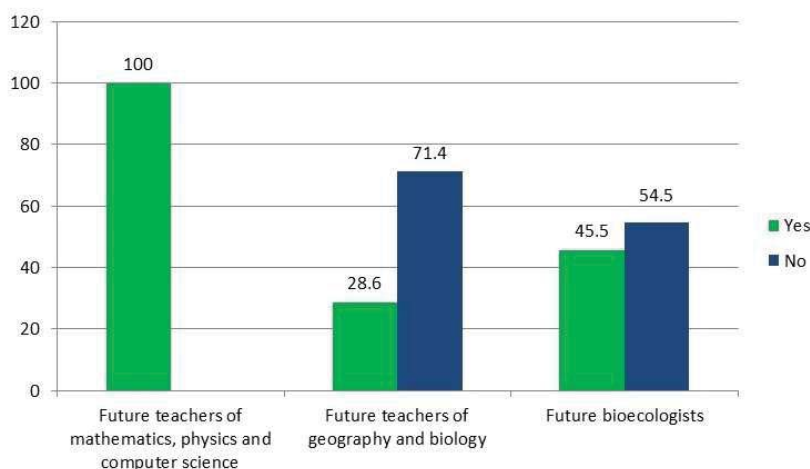
The analysis of the questionnaires (the answers to the questions were not offered — the students were free to write down the answers themselves) showed that for 14.3% of future teachers of mathematics, physics and computer science, during the game, knowledge in the field of geography was the most useful, for 85.7% — in the field of biology. 81.8% of bioecologists among the useful disciplines called geography and 18.2% wrote geography and biology simultaneously. The widest range of answers was received from future teachers of geography and biology: 23.8% of students choose geography as the most useful discipline, 47.6% — biology, 9.5% — zoology, 4.8% — molecular biology. The remaining 4.8% said that none of the disciplines were useful to them.

The hardest for 28.6% of the future teachers of mathematics, physics and computer science was to keep patience and for 71.4% is to stop the cure research. 19.1% of the future geography and biology teachers and 81.8% of future bioecologists considered the infecting the cold regions of the planet as hardest thing in the game and 9.5% and 27.3%, respectively, answered that the most difficult was understanding of the mechanism of the game. The vast majority (71.4%) of the future geography and biology teachers indicated as the hardest thing in the game the choice of strategy.

In the group of the future teachers of the mathematics, physics and computer science 14.3% of students felt the lack of knowledge in biology, 14.3% — in logics, 42.9% — in skills to play the strategy games and 28.5% answered “I know enough”. In the second group (future teachers of geography and biology) the most popular answer was logics (66.7%). Another 14.3% wrote virology and bacteriology, 9.5% — medicine and 9.5% — “I know enough”. 90.9% of the future bioecologists lacked the knowledge of geography and the rest 9.1% said “I know enough”.

Only 28.6% of the future teachers of geography and biology found an in-game scenario possible in the real world (Fig. 5). Almost a half of the students-bioecologists (45.5%) and all the students-teachers of mathematics, physics and

computer science believe in the opportunity of such event in reality. We don't know how real exactly this scenario can be, but believe (observing the COVID-19 pandemic and the forecasts of futurologists and epidemiologists) that is rather real. The emergence of new strains of pathogens and antibiotic resistance makes this probability higher than 50%. Low percent of students with answer "yes" in the first case might be explained by the lack of knowledge in biology and medicine. Future teachers of mathematics, physics and computer science even rated the probability in their answers (57.1% of students considered probability is 100%; 28.6% — 50% probability and 14.3% — 30% probability). At the same time, such high values among future mathematics, physics and computer science teachers are probably also associated with an insufficiently deep knowledge of biology and medicine (they know little about international organizations for the control of the spread of diseases and their efforts). The most adequate assessment was given by students of bioecology.



**FIGURE 5.** Students' assessment of the probability of realizing a game scenario in the real world (%).

To the last question "Will you use this game in your future professional activities?" most of the students of geographers-biologists and bioecologists answered positively (85.7% and 81.8% correspondingly; bioecologists naturally answered in the style "we would use if we worked in the field of education"). Persons who responded negatively argued their point of view that games distract from the study of the material, weaken discipline and even lead to degradation of cognitive abilities (sic!). 28.6% of future teachers of mathematics, physics and computer science said "yes" because this game contributes to the development of logics. The remaining 41% said "no", because either they do not see a way to use this game in the lessons in their disciplines, or they are against the use of video games in teaching (that might be connected with too "traditional" style of lessons in pedagogy in the most Russian universities and its influence on students' mindset).

All students enjoyed taking part in this study in one way or another. In additional comments, 90% of them noted the undoubted benefits of the game, as it develops logical thinking, broadens erudition and raises the level of motivation, which is sometimes extremely difficult to achieve with traditional means in our time.

## CONCLUSION

The results of this study give us unambiguous positive answer for our question "Can we use entertaining technologies (video games) while teaching geography and biology of schoolchildren and students?". The use of video games, i.e. the implementation of the concept of edutainment in the educational process, contributes to increased motivation, easier and faster assimilation of material, broadening of erudition by learning new facts. In this particular case (Plague Inc.), knowledge of the physical, climatic, political and economic maps of the world is extremely important. Students who had training in geography had advantages in some aspects, since they knew about international organizations that are responsible for containing the spread of diseases, about the climatic conditions of different regions and countries, their level of socio-economic development (and, accordingly, the level of development of science and medicine, financial capabilities) and could change the pathogen as it was necessary to win. We can say

that the use of this game contributes to the deepening of the general, synthesized picture of the structure, essence of the world.

Knowledge in the field of biology is no less important — the characteristic features of various pathogens make it possible to choose a winning strategy faster and more successfully. Knowledge of anatomy and physiology facilitates the evolution of the selected “plague”, and the combination of symptoms necessary for the spread of the disease in certain regions of the planet is a clear example of the integration of geography (climatology, transport routes, various sectors of the economy, etc.) and biology, i.e. it actively contributes to the development of connections between different disciplines.

There was a certain lack of knowledge in various fields of geography and biology among even those students for whom these disciplines are priority. As a rule, study participants experienced difficulties with the most remote and, accordingly, the least known to them regions.

Further integration of video games into education is necessary, since a small part of their potential has not yet been revealed, despite the obvious success of gamification over the past decade. Therefore, the primary target is to develop the concept of edutainment, the main direction of which should not be the development of amateur and indie games, but the integration of large suitable projects (especially AAA) into the educational process. This direction is perfectly combined with the use of not only documentaries, but also fiction, science fiction and especially science fiction films. Further development of this area will be accompanied by a gradual increase in the share of VR technologies.

It is also important to timely select suitable games for a particular event in the world, superimposed on the study of a specific topic. This means that the future teacher must be to some extent a gamer and actively use and test digital technologies not only within the framework of their working hours, but also in their everyday life. It also means that he needs to closely monitor global and local trends.

As the research has shown, the most prepared were students of non-pedagogical profile — they showed the best time and the highest percentage of successful attempts in the game. This circumstance should indicate that it is necessary to strengthen the profile disciplines training (in this case these are cycle of geography and biology) by reducing the time for teaching the disciplines of the pedagogical cycle.

It is undoubtedly extremely important that the vast majority of students expressed their desire to use Plague Inc. (and other video games) in their professional activities. One year after the experiment, two students in their last year of study had already got a job at the school and reported that they used this game in the classroom, whose topics fit the plot of this project.

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