# MXJ1

FYP Final Report

# Designing a Serious Game to Promote Citizen's Policy Understanding during a Public Health Crisis

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# Abstract

This final year project is to design and develop Policidemic, a serious game that simulates policy-making during the COVID-19 epidemic. The game was created with the aim of promoting players' policy understanding and alleviating mental health and policy compliance issues. The game's design requirements, including the game rules and user interface, were established, and models were created to calculate pandemic data and citizens' satisfaction. After conducting extensive testing, the game was found to positively impact players' mental health and attitudes towards policies. Policidemic is considered a useful tool for future public health crises.

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# 1 Introduction

## 1.1 Overview

Throughout human history, various public crises have arisen, prompting governments to implement special policies that can lead to negative outcomes and discrepancies between citizens and their governing bodies. This report aims to utilize the COVID-19 pandemic as a case study due to its global scale and immediate relevance. In view of the epidemic of COVID-19, special policies such as isolation, lockdown, and compulsory testing have been executed by governments for disease control purposes, bringing negative effects to citizens whose daily routines are affected [1]–[3]. The most obvious public health interventions, including the government's stay-at-home order and lockdown measures, have contributed to a wide range of mental health problems [1], [2]. For example, data from a web-based survey indicated that during Italy's 2020 lockdown, 37% of Italian participants experienced post-traumatic stress symptoms, while 17.3% experienced depression, 20.8% experienced anxiety, and 21.8% experienced high perceived stress. These outcomes were associated with a number of risk factors, including being under quarantine, working activities being interrupted, or other stressful issues related to the pandemic or lockdown measures [2]. In addition, a general reduction of ability and motivation for policy compliance, defined as citizens' willingness to cooperate with a government's requests [4], [5], was observed

around the globe, regardless of the demographic or socio-economic background of the citizens [6], thus affecting the effectiveness of policy implementation. Citizens' different interpretations of the policies has led to frustration with various aspects of policies, such as the rationale behind them, so many citizens have been reluctant to comply with the policies in the end [3].

One way to mitigate the detrimental effects (e.g., mental health issues and less policy compliance) caused by disease control policies is to enhance citizen's policy understanding, which refers to the comprehension of the rationale behind policies [4], [5], [7]–[10]. Research has shown that enhancing citizens' understanding of what is happening can help them overcome psychological damage caused by situations such as lockdowns or confinements [7]–[9]. Additionally, a deeper policy understanding can serve as a motivating factor to enforce policy compliance [4], [5], [10], as citizens better informed about the rationale behind a policy are more likely to be aware of the personal benefits they will receive from adhering to the policy [11]. Thomsen et al. also note that an improved understanding of a policy enables citizens to better identify what actions they should conduct to comply with it [11]. Otherwise, they would be less willing to do so [4].

## 1.2 Literature Survey

This section examines three major approaches adopted to enhance citizens' policy

understanding.

### 1.2.1 Social Media

The use of social media in government crisis management has been widely discussed. Social media, due to its nature as an open and participatory communication platform, offers benefits to interactive communications between governments and the public, promoting citizens' political engagement, which cultivates their understanding of actions taken by their governments [12].

Several researchers have dived into the effects of social media on people's political engagement and understanding during the crisis [12], [13]. One study showed the effectiveness of government-generated videos on the platform Bilibili to promote youth engagement [13]. Based on related studies about the positive effect of engaging and educating youths through integrating educational and social issues in social media in other fields [14]–[16], the research hypothesized the positive impact of recreational videos on youth engagement. Based on the fact that different video content satisfies different cognitive and affective needs, and affects citizens' engagement [12], the research hypothesized a relationship between video content and the effectiveness of engagement. Quantitative and qualitative approaches were adopted to discover the relationships between independent variables, such as video content and category, and dependent variables, including interaction, feedback, and sharing among the audience,

and proved the hypothesis.

While the study identified the positive association between government-generated recreational videos and young citizens' engagement, it pointed out that among the five studied topics, knowledge popularization and guidance received the most significant number of shares, which indicates the information that is important for the public. At the same time, however, it is not discussed and liked as frequently as the other studied topics, which suggests that knowledge popularization and guidance from the government are not attractive to most of the citizens [13]. The gap between the needed information for understanding the crisis and related policies and its unattractiveness in social media is present, resulting in a lack of engagement in promoting such understanding [13].

### 1.2.2 Chatbots

Chatbots are defined as agents with the ability to interact with users by understanding a spoken or typed language and simulating human conversion [17]. With the advancement of AI technologies and the multitude of data available, chatbots now have the capability of completing more complicated tasks, leading to their adoption by the governments in various areas such as health care, education and disaster management [17]. In fact, five use cases of chatbots in handling citizens' inquiries have been pointed out [18], some of which, including answering and routing requests, help to

promote communication between government and the public.

Chatbots can be built to allow governments to disseminate information in an automated way, saving the human resources required to deliver similar services [19]. They also promote public engagement by providing an interactive channel to gather feedback from the citizens, which can be used as support for policy-making practice [19]. In addition, recent advancements in chatbot technology have made them to be more expressive and more suitable for complicated, ambiguous and uncertain interactions, which used to be handled by traditional channels, such as face-to-face discussion or phone calls with government officials. This can further stimulate the use of chatbots in related fields [17].

Despite the interactiveness and convenience provided, the effectiveness of chatbots in public affairs is highly dependent upon proper use of the technology by both citizens and government officials [19], [20]. Being unfamiliar with the technologies reduces the users' trust of chatbots and discourages them from using chatbots as a channel to express opinions and requests [21]. Training of digital skills has to be conducted to ensure that people have the expertise and to maintain the service quality [22].

### 1.2.3 Serious Games

**Serious Games** are a category of games not primarily designed to entertain [23], [24]. They utilize game elements (e.g., storyline, rewards) to facilitate learning and

transform player behaviors and perceptions on specific topics [25]–[29]. Serious games are not meant to be dull or solemn; instead, they are designed to create enjoyable and immersive environments to effectively promote learning and understanding [25], [27], [30]. For example, Hrehovcsik et al. comprehensively examine a serious game, "The Mayor Game," that provides policymakers with training on strategic dilemmas in crisis management. The results indicate that "The Mayor Game" significantly promotes the thought process and dilemma awareness [31]. Additionally, "Darfur is Dying," a serious game developed by the International Crisis Group in cooperation with the Reebok Human Rights Foundation, helped raise public awareness of the crisis in Darfur [32]. In short, serious games have proven to be a promising way to advance citizens' understanding of COVID-19 policy, which is the reason why we chose to develop a serious game.

Moreover, serious games have the potential to address the aforementioned gaps of social media and chatbots (i.e., lack of engagement and need for expertise). "The Mayor Game" has provided participants with an engaging and motivating experience to think critically about a situation [31]. "Darfur is Dying" is easy to play so everyone can use it, even people with no previous experience [32]. Thus, in our game, we also provide an engaging and motivating user experience.

## 1.3 Objectives

In this project, we developed a PC-based serious game to promote citizens' policy understanding during public health crises such as COVID-19. Our hope is to alleviate users' mental health concerns and improve policy compliance.

To achieve the goal, we mainly focused on the following objectives:

- Define a model for prediction of data after the execution of policies by users.
- Design and implement a user-friendly user interface, including visualization of data in the scenes.
- Design and develop an engaging game storyline and logic.

# 2 Methodology

## 2.1 Design

To effectively promote citizens' policy understanding during COVID-19 and fill the gaps of social media and chatbots, we derived the following design requirements and their corresponding design choices for the serious game to guide the design process (as shown in Table 1).

| **Design Requirements** | **Design Choices** |
|---|---|
| The serious game should be engaging and motivational | Storyline |
| | Provision of choice |

| | |
|---|---|
| | Provision of feedback |
| The serious game should be easy to play | Data visualization |
| | Simple interaction mode |

Table 1. Design requirements of the serious game and corresponding design choices

Here are the detailed explanations of the design choices:

**Storyline**

Based on the purpose of the game, serious games employ storylines to facilitate the learning of specific content [33]. Storylines are crucial to optimize learning [34], as they contextualize the skills and goals to be mastered, which promotes enjoyment, immersive learning, and motivation for learners [25], [28]. Research has shown that incorporating learning opportunities into story content enhances intrinsic motivation to learn [35].

Thus, our game has a storyline to simulate a situation where players become policymakers during COVID-19 who must adjust a series of disease control policies to prevent the spread of the disease. They encounter different types of dilemmas along the way, culminating in an open-ended ending. We believe that having players on the side of policymakers allows them to better understand policy because it allows them to learn from a completely different perspective on policy and the situation. Where previously they only had the experience of adhering to policy, now they can experience making policy, increasing the synergy between them and policymakers.

**Provision of choice**

Research considers setting up options for learners as an essential design element for serious games to facilitate learning efficiency [25]. According to self-determination theory, offering choices promotes intrinsic motivation and engagement in serious games [36], as choices give participants a sense of control and autonomy for their own experience [25]. Our serious game provides players with a set of policies, and the players can adjust their strictness.

**Provision of feedback**

Providing feedback is identified as one of the main strengths of serious games [29], as it can influence players' learning behaviors for long-term, challenging goals [25]. Continuous feedback related to players' progress to the ultimate goals will foster their intrinsic motivation as well [37].

Our game simulates the consequences of each choice made by the player, and continuously updates data about COVID-19 (e.g., the number of people infected and dead of COVID-19) to provide them with timely and incessant feedback.

**Data visualization**

Data visualization, which transforms abstract data into visual forms, can significantly reduce the cognitive load of humans [38], [39]. When applied to serious games, it can be deduced that data visualization techniques can effectively free players

from analyzing complex information, making the game accessible to everyone, even those with little knowledge of the field.

Our game introduces data visualization technology by visualizing the COVID-19 data (e.g., the number of people infected or dead of COVID-19) on a map of China, intuitively presenting players with the pandemic situation among different provinces in China.

**Simple interaction mode**

To make our game easy to play, we designed our interaction mode to be as simple as possible, only requiring players to analyze the data and situation intuitively presented on the map and to set the values of the policies, without requiring them to conduct additional actions.

## 2.2 Implementation

The Implementation Phase included the following aspects:

### 2.2.1 Devise the Game Rule

Considering the design requirements, we came up with a set of game rules, which are the foundation of other implementations. The following rules will be shown to the players before the player starts the game: "Players will travel back to March 2022, when the highly contagious Omicron virus began to wreak havoc in Shenzhen and Shanghai. Players will be the main makers of epidemic prevention policies, who need to analyze the epidemic

situation in China at that time, formulate a series of policies to prevent the spread of Omicron, and also need to consider the impact of the policy on residents (mainly reflected in the citizen satisfaction, one metric in this game). For example, if a city is locked down for a long time, it will cause a serious decline in citizen satisfaction. Therefore, players will always need to pay attention to both the COVID information and citizen satisfaction. If the daily infection cases in any city exceed a threshold or citizen satisfaction in any city falls below a threshold, the game will be sentenced to a loss. If the player is not judged to lose and advances the timeline to a threshold, the game is won". We tuned the thresholds mentioned above to maintain the game difficulty within a reasonable range.

### 2.2.2 Build the Model for Data Prediction

Echoing the game rules, we built a backend model to predict daily infection cases, total deaths, and user satisfaction. Following existing literature [40], we showed the impact of the policy on residents using the stringency index, which is defined as the strictness of government policies. For every day in the game, the model takes the COVID information (i.e., infections and deaths) of previous days and the stringency index of the day as inputs to predict the COVID information (i.e., infections and deaths) and citizen satisfaction of the new day. Moreover, the frequency of policy change also affects citizen satisfaction. If the government changes the policy very often, citizen satisfaction will drop significantly.

Initially, we had contemplated utilizing machine learning techniques to construct models based on real-world datasets, in order to achieve more precise and realistic predictions. However, due to the fact that machine learning models are less manageable than self-defined models, and that our game does not necessitate the same level of accuracy as scientific predictions, we opted for self-defined models instead. This allowed us to have better control over the projected trend of the data. To introduce non-linearity and enhance the comprehensiveness of our model, we integrated complex functions like logarithms into it.

### 2.2.3 Develop the User Interfaces and Data Visualizations

The user interfaces were developed using the Unity game engine [41]. The game mainly consists of two scenes, the starting scene and the main scene. The former provides users with basic information, while the latter displays the game elements.

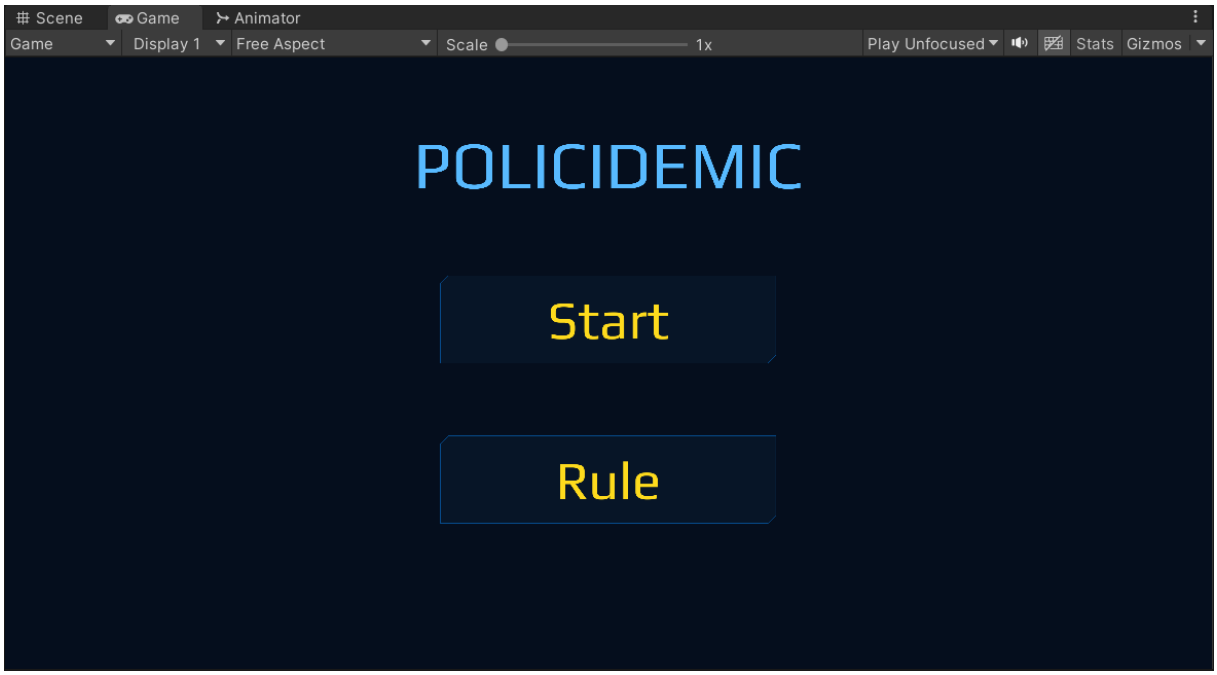


Figure 1. The start scene


Figure 2.1. Background information is shown as mouse hovers over a city


Figure 2.2. Selection is confirmed by mouse click. Data panel is updated and control panel is enabled to allow policy change


Figure 2. The main scene. Part 1 is the map, part 2 is the data panel, part 3 is the news and social media panel, and part 4 is the control panel.

To better visualize the data and provide efficient user interactions, we included four panels on the main scene:

1. The map in the middle provides an overview of all cities included in the game. Each city is associated with a red point whose radius indicates the total infection cases in the city. Some warnings will pop up when the player is about to lose. In our game, the player enacts policies at the city level rather than the country level.

To select a specific city, the player needs to hover on a red point, and a pop-up will be shown to provide background information about the corresponding city (as shown in Figure 2.1). The selection will be confirmed after players click on the red point, and other panels will be updated based on the selection to show the data and policies about the city (as shown in Figure 2.2). The overall data and policies will be shown when the player clicks on the area with no red points.

2. The data panel on the left visualizes COVID-related data and citizen satisfaction. The name of the place and the current date are shown at the top. The exact values of daily infection cases and total deaths are displayed, and their trends are shown in line charts. The satisfaction level is shown both as numerical values and waves to provide intuitive and precise data to the player. Note that when this panel shows the overall data of the country, the new cases and total death number are the sums over all cities, and the satisfaction level is an average from all cities.
3. The news and social media panel on the right provides qualitative feedback to the player by showing the opinions of the press and the general public about the pandemic and the policies. The social media part simulates Weibo (微博), one of the most used platforms in China.
4. The control panel on the top enables the player to set policies for each city. When

a city is selected, the panel is enabled, and the values are updated to the corresponding ones (as shown in Figure 2.2). The player adjusts the policies via the slide bars. Note that since the player is not allowed to adjust the policies at the country level, the panel will be disabled when no city is selected, and the values are displayed as the average values across the country.

During the implementation of the user interface, we utilized an iterative development approach. Initially, we constructed the basic layout of the user interface, which included the China map and all the panels. Subsequently, we made adjustments to improve the effectiveness of the data visualizations and user experiences.

Originally, we employed a double legend in the line chart to save space. However, we later changed to a single legend to avoid confusion among players. Additionally, we modified the interactive format from popping up warnings and letting players make decisions to using slide bars. This change was made to prevent confusion when multiple decisions needed to be made simultaneously. Since the single China map with red dots did not provide a complete view of the situation, we added the warning feature to enable players to respond quickly to emergent situations.

While implementing the user interfaces, we observed that certain interaction modes (such as hovering) were not suitable for a smartphone platform. Consequently, we made the decision to switch to a PC as the game platform. This platform is more stable and

better suited for implementing interactions in a manner that is both effective and user-friendly.

### 2.2.4 Develop the Logics of the Game

We adopted C# scripts [42] to develop the logic of the game. Based on the game rules and the interaction modes of the user interfaces, we have implemented the game logic as shown in Figure 3.

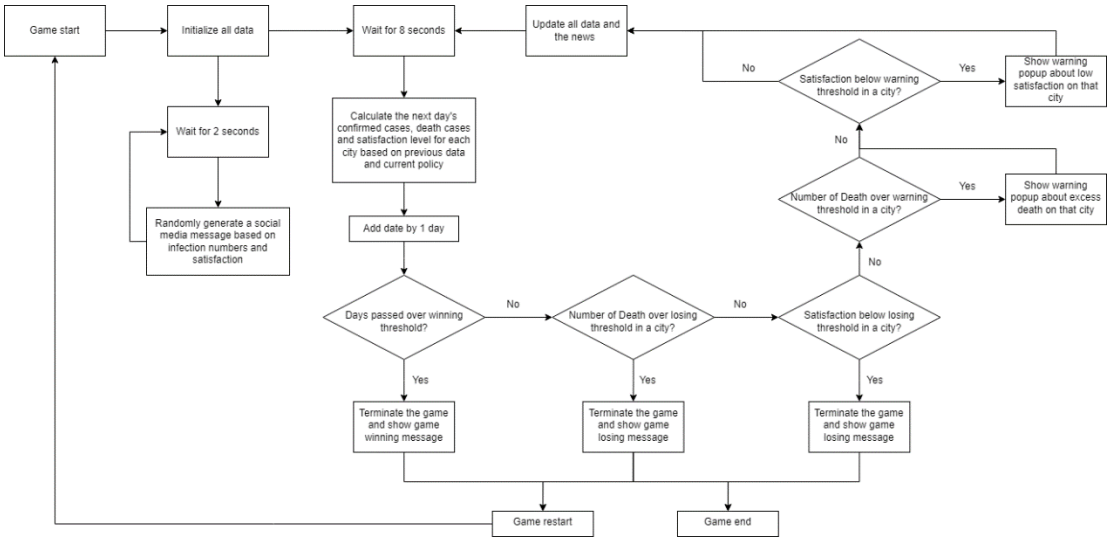


Figure 3. Game Logic Flow

The main game loop controls the update of data for each day in the game. Each iteration of the loop takes 8 seconds to provide players with sufficient time to examine the current situation. The backend model predicts new data for each city. After that, the terminating conditions will be checked. If any of the terminating conditions mentioned in the game rules are met, the game will end. When the game metrics of a city reach warning thresholds, some popups are instantiated and attached to the city.

Apart from the main game loop, there is a separate loop controlling the update of the social media content. The sentiment of the comments presented on social media changes as citizens' satisfaction alters. When citizens' satisfaction is low, the comments mainly consist of complaints and railings. When citizens' satisfaction rises, the contents display citizens' faith and optimism in government.

### 2.2.5 Develop Other Functionalities

In addition, we incorporated several functionalities to enhance the game process. To enable players to thoroughly evaluate the situations, we implemented a pause button that suspends all time-related operations in the game. Furthermore, we introduced a speed up button to allow players to adjust the pace of the game to their liking.

To aid players in understanding the game mechanics, we included the game rules on the start scene for easy reference. We also developed a game tutorial that players are required to complete before entering the game for the first time. This tutorial provides detailed and intuitive guidance on how to play the game and can be accessed at any time during the game for reference.

## 2.3 Testing

When conducting tests, we primarily adhered to our implementation orders. To facilitate both edit mode and play mode testing, as well as to generate code coverage

reports, we utilized the Unity Test Framework [43], which is a built-in framework in Unity. We conducted both unit testing, which focuses on the components of the classes, and integration testing, which focuses on the functioning of the features.

### 2.3.1 Test the User Interfaces

The purpose of testing the user interface is to ensure that the player's interactions with the game are processed accurately. Specifically, we tested three functionalities of the user interface using the Unity Test Framework: city selection, policy changing, and displaying city information.

For the city selection feature, we created a play mode test case that simulated a click event on the button for Shanghai. Since selecting a city affects both the data panel and the policy control panel, we confirmed the correctness of the selection by verifying the current city index of these panels after the selection. We also verified that the panels could display the overall data when clicking on the China map.

To test the policy changing features, we implemented a play mode test case that selected Shanghai, changed the value of its school closing policy index to 1, and checked the current value of the policy index in the data manager using the `getPolicyIndex` function. We confirmed that the feature functioned without errors.

To test the displaying city information features, we utilized both edit mode and play mode testing. First, we performed edit mode testing to ensure that all information about

each city was stored and returned correctly. We designed test cases for each get function in the `InfoBlock` class. Then, we implemented a play mode test case that simulated a mouse enter event on Shanghai and verified that the city name, description, population density, and GDP were correctly displayed on the information block.

During testing, we also manually checked the operations of these features, as well as other displays in the user interface, to ensure that they functioned well from the end-users' perspective.

### 2.3.2 Test the Model

The model is the central component of the game that predicts all data, making it crucial to ensure its correctness through testing. To verify the accuracy of the computations, we conducted unit testing using the Unity Test Framework. As the model is not linked to game operations, we adopted edit mode testing. We tested each function of the `Model` class with test cases that attempted to cover most of the branches. The testing results confirmed the overall functioning of the model, although we identified and corrected some minor mistakes.

### 2.3.3 Test the Game Logic

The game logic was primarily implemented in the `DataManager` class, and we conducted testing in both edit mode and play mode. During edit mode testing, we performed unit testing by testing all the get and set functions in the class. In play mode,

we focused mainly on the warning and terminating conditions.

To test the satisfaction warning, we temporarily adjusted the warning threshold to 100% and developed a test case that changed the first two policies to the strictest value in Shanghai. We checked whether a warning was displayed in the next game loop iteration. To test the death warning, we temporarily changed the threshold to 0 and used a test case to wait for the total number of deaths to be over 0. We checked whether a death warning was present.

Testing the terminating conditions was similar to testing the warnings. For the failed conditions, we followed the same process by setting the satisfaction threshold to 99% and death threshold to 1. For the success conditions, we first set the threshold to 1 day and developed a test case to wait for one game loop iteration. We checked whether the game end canvas was displayed in the test case instead.

After executing all the test cases, we found that the code coverage of most of the classes we implemented was around or over 90%, except for some irrelevant classes. This indicates that our testing phase was conprehensive and we have discovered most of

| Name | Covered | Uncovered | Coverable | Total | Line coverage | Covered | Total | Branch coverage |
|---|---|---|---|---|---|---|---|---|
| + EditModeTests | 203 | 0 | 203 | 422 | 100% | 0 | 0 | |
| − Scripts | 1282 | 775 | 2057 | 3717 | 62.3% | 0 | 0 | |
| City | 11 | 0 | 11 | 46 | 100% | 0 | 0 | |
| DateContent | 3 | 0 | 3 | 12 | 100% | 0 | 0 | |
| News | 47 | 0 | 47 | 73 | 100% | 0 | 0 | |
| RandomNumber | 13 | 0 | 13 | 38 | 100% | 0 | 0 | |
| UpdateInfection | 5 | 0 | 5 | 15 | 100% | 0 | 0 | |
| Wavecircle | 8 | 0 | 8 | 34 | 100% | 0 | 0 | |

Figure 4. The code coverage report for the tested classes, including the DataManager, Model, and UI Controllers. The report indicates that the line coverage for these important classes is acceptable, which suggests that our tests have effectively covered most of the code in these classes.

the bugs in the game.

## 2.4 Evaluation

After we had finished all the testing, we conducted a user study to evaluate how well the system fulfills our objectives:

1. Can the game relieve user's mental health problems caused by disease-control policies?
2. Can the game help to increase citizen compliance with disease-control policies?

### 2.4.1 Participants and Procedures

A total of 8 participants (3 females, 5 males; mean age: 20.37, SD=1.87) were recruited for this study through online advertising, social media, and word-of-mouth from a local university. All participants reported experiencing mental health issues and compliance issues regarding disease-control policies in mainland China during 2021-2022.

The study was conducted through face-to-face offline settings. The experiment began with a questionnaire, which was developed to quantitatively evaluate the mental health and policy compliance of participants. The questionnaire was adapted from CoPaQ [44], a valid measurement of the psychosocial impact of the COVID-19 epidemic

on individuals. Mental health issues caused by the COVID policies were assessed through three components, namely PTSD symptoms, sleep disturbance, and substance use. Policy compliance was evaluated based on COVID-19 political and institutional trust and COVID-19 conspiracy beliefs. All items in the questionnaire were assessed using 7-point Likert scale questions. The questionnaire is included in the Appendix.

Following the questionnaire, participants were invited to engage in a 20-minute session playing *Policidemic*. Subsequent to a three-day interval following gameplay, the user re-administered the questionnaire. This decision was informed by the questionnaire's nature, which encompasses a multitude of daily behaviors that necessitate adequate time for users to observe and report on, such as sleep patterns. The results of the pre-study and post-study questionnaires were analyzed and compared to generate findings.

### 2.4.2 User Study Results

After evaluating various aspects of mental health issues related to disease-control policies (as shown in Table 2), we identified the significance of certain PTSD symptoms. Our findings indicate that participants experienced significantly less powerful images or memories of the COVID-19 policy-related experiences being replayed after playing *Policidemic* (Mean = 3.63, S.D. = 0.74, $p = 0.034$) compared to before playing *Policidemic* (Mean = 4.38, S.D. = 0.92, $p = 0.034$). Additionally,

participants reported feeling significantly less "super-alert", watchful, or on guard because of the COVID-19 policy-related experiences after playing *Policidemic* (Mean = 2.88, S.D. = 0.64, p = 0.014) compared to before playing *Policidemic* (Mean = 3.63, S.D. =2.88, p = 0.014). However, for sleep disturbances and substance use, we did not observe significant changes in these measurements. This may be attributed to the fact that these are daily behaviors that are influenced by plenty of factors, and participants may not alter these behaviors without significant external stimuli.

| Aspect | Measurements | Before Mean/S.D. | After Mean/S.D. | Statistics W | Statistics p-value |
|---|---|---|---|---|---|
| PTSD symptoms | Upsetting pandemic dreams | 4.25/1.49 | 3.63/1.19 | 0 | 0.059+ |
| | COVID-19 flashbacks | 4.38/0.92 | 3.63/0.74 | 0 | 0.034* |
| | Internal avoidance | 4.13/0.64 | 3.63/0.52 | 0 | 0.102- |
| | External avoidance | 3.88/0.35 | 3.63/0.52 | 0 | 0.157- |
| | Hyper-vigilance | 3.63/0.52 | 2.88/0.64 | 0 | 0.014* |
| Sleep disturbances | Sleep onset difficulties | 4.00/1.69 | 3.63/1.06 | 4.50 | 0.408- |
| | Sleep maintenance difficulties | 3.63/1.06 | 3.38/0.92 | 2.50 | 0.317- |
| | Early morning waking | 3.00/0.76 | 3.13/0.83 | 2.00 | 0.564- |
| Substance use | Excessive alcohol consumption | 4.25/0.46 | 4.25/0.46 | 0 | 1.000- |
| | Increased drug use | 4.00/0.00 | 4.00/0.00 | 0 | 1.000- |
| | Chain smoking habit | 4.25/0.89 | 4.00/0.53 | 1.50 | 0.414- |
| | Strong addiction cravings | 4.38/0.92 | 4.13/0.35 | 1.50 | 0.414- |
| | Loss of substance control | 4.25/0.46 | 4.13/0.35 | 0 | 0.317- |

Table2. The quantitative results of participants' mental health, where the p-values (-: p > .100, +: .050 < p < .100, *:p < .050, **:p < .010) are reported.

With regard to the participants' policy compliance (as shown in Table 3), we observed significant changes in most of the measurements. Participants displayed significantly more trust in the political leadership, with feelings that the political leadership was standing up for them (p = 0.019). Moreover, participants reported significantly more confidence and trust in public institutions (p = 0.018), politicians

(p = 0.017), and democracy (p = 0.046). Furthermore, participants reported significantly less belief that news and reports on the COVID-19 pandemic were being deliberately withheld (p=0.027). In terms of conspiracy beliefs, participants reported significantly less belief in alternative or secret explanations for COVID-related events (p = 0.009), as well as significantly less belief in the association of the COVID-19 pandemic with biological weapons (p=0.016) or deliberate population reduction (p=0.040).

| Aspect | Measurements | Before | After | Statistics | |
|---|---|---|---|---|---|
| | | Mean/S.D. | Mean/S.D. | *W* | p-value |
| Political and institutional trust | Trust in political leadership | 2.63/1.30 | 4.88/0.64 | 0 | 0.019* |
| | Confidence in democracy | 3.38/1.19 | 4.38/0.74 | 0 | 0.046* |
| | Trust in public institutions | 2.50/1.69 | 4.88/0.83 | 0 | 0.018* |
| | Perceptions of media transparency | 2.13/1.25 | 4.25/1.39 | 0 | 0.027* |
| | Trust in politicians | 2.63/1.41 | .63/0.92 | 0 | 0.017* |
| Conspiracy beliefs | Distrust in media | 5.13/0.64 | 4.25/1.28 | 2.00 | 0.068+ |
| | Belief in alternative explanations | 5.75/1.16 | 4.00/1.20 | 0 | 0.009* |
| | Biological weapons | 4.13/0.99 | 2.63/0.52 | 0 | 0.016* |
| | Superpower competition | 4.13/1.36 | 3.00/0.53 | 0 | 0.059+ |
| | Population reduction | 3.88/1.13 | 2.63/0.74 | 2.00 | 0.040* |

Table3. The quantitative results of participants' policy compliance, where the p-values (-: p > .100, +: .050 < p < .100, *:p < .050, **:p < .010) are reported.

# 3 Discussion

The serious game, *Policidemic*, was found to have had a positive impact on the mental health of participants who were affected by COVID-related policies, particularly with regards to COVID-related PTSD symptoms. Additionally, the game significantly enhanced policy compliance among participants by promoting trust in

political institutions and reducing belief in COVID-related conspiracy theories. In this section, we have combined user behaviors and comments with our quantitative results to further explore the capabilities of *Policidemic* and what limited it to better fulfill the objectives. We have analyzed various aspects of *Policidemic* and derived design considerations for the further development of serious games similar to *Policidemic*. We have also summarized the limitations encountered during the final year project.

## 3.1 Content Enrichment and Playability

During the user study, it was observed that despite the set duration of 20 minutes for the playing session, most participants completed their exploration in a relatively shorter time. One participant made a quick comment stating that "It appealed to me at first, but soon became boring since there was not too much to play with." Overall, *Policidemic* had a relatively monotonous gameplay and limited features, which hindered users from being more engaged with the game, and thus, gaining a deeper understanding of the policies. The game had only one main plot and no side plots, with minimal random events in the main plot. Users were only able to adjust the policies repeatedly and monotonously, leading to a quick loss of interest. Another participant's comment supported this observation, stating that "This game feels more like a stat panel than an immersive game."

However, the news and social media panel in our game was a bright spot, as two

participants mentioned that the qualitative feedback provided in the social media panel helped them to better adjust the policies. This panel enhanced the playability of *Policidemic.*

Therefore, while the primary goal of a serious game is not solely for entertainment purposes, good playability is still an important design consideration in implementing such games. Developers should enrich the storyline and add interesting interactive features to enhance the user experience and enable better exploration of the essence of serious games.

## 3.2 Visualization Techniques

Visualization played a crucial role in *Policidemic*, providing real-time feedback to participants and incentivizing them to engage with the game. The data panel, which included line charts and bubbles, effectively conveyed information on infection cases, deaths, and citizen satisfaction. The red dots on the map of China represented the total number of infection cases in each city, providing users with an overall understanding of the pandemic situation in China.

However, one participant said that "*The red dots were quite messy after they got big. I seldom looked at them because they had nothing to do with my objectives. What I frequently checked is the left chats because they were simple and effective*". Indeed, the

red dots could not provide feedback on the terminating factors of *Policidemic* (i.e., daily infection cases, daily death, and citizen satisfaction), and they may become messy and negatively affected the aesthetic of the game in some circumstances. As a result, users may have found this visualization less appealing.

Based on these insights, two design considerations for visualization techniques in serious games could be derived. First, visualizations should be simple and clean, as users were less likely to engage with messy and complex charts. Second, visualizations should be integrated with the game logic and have meaningful interactions with other game elements. Otherwise, they could be perceived as isolated and insignificant features and went unnoticed.

## 3.3 Idea of Perspective-taking

*Policidemic*'s ability to enhance users' policy understanding was based on its idea of perspective-taking. In the game, users put themselves in the shoes of policymakers and thought deeply about the actions needed to improve the situation. By experiencing the uncertainty and difficulty of controlling the COVID-19 pandemic firsthand, they also gained an appreciation for the complexity of managing public sentiment and the dual nature of public opinion. These aspects were not fully realized by users when they were simply citizens, but *Policidemic* provided them with an opportunity to evaluate events from the perspective of policymakers. As a result, they gained a more

comprehensive understanding of the situation and developed greater empathy for policymakers. One participant's feedback reflects this sentiment, "*I realized that no matter what I did, there would always be someone criticizing me. I finally understand how difficult it is to be a policy maker*".Therefore, the concept of perspective-taking is a valuable design approach when developing tools to enhance people's understanding of complex issues.

## 3.4 Limitations

Our design and studies have several limitations. First, we did not apply a machine learning model with a large dataset to predict infection and death cases. This can result in data that is greatly inconsistent with reality in some cases, which could reduce user engagement with the overall game. Second, our user study participants were primarily young adults aged 18-23, which could introduce bias due to the skewed age distribution. More experiments with diverse user groups should be conducted to improve the accessibility and inclusiveness of Policidemic. Third, the evaluation of sleep disturbance and substance use in the questionnaire can be influenced by many factors in real life. Although the questions pointed out that the evaluation was based on COVID-19 policy-related experiences (e.g., "I have difficulty sleeping through the night due to the COVID-19 policy-related experience"), users may not be able to distinguish whether changes in their behavior are due to COVID-19 policy-related

experiences. This could cause some bias in the evaluation.

# 4 Conclusion

## 4.1 Achievements and Accomplishments

In this final year project, We developed a serious game called Policidemic, which simulates the process of policy-making during the COVID-19 pandemic. The game aims to enhance players' understanding of policies, thereby mitigating mental health and policy compliance issues. We established various design requirements for the game, and devised the game rules and user interface. We created non-linear models to calculate pandemic data and citizens' satisfaction with reasonable accuracy. Additionally, we explored different data visualization techniques and selected the most suitable ones to present information to players in an intuitive manner.

After implementing the game, we conducted extensive testing on its components and functionalities. We also conducted a survey to evaluate the game's effectiveness in achieving our goals, and the results confirmed that the game has a positive impact on players' mental health and attitudes towards policies. Although the COVID-19 pandemic has largely subsided, we believe that this game can be used as a tool to benefit citizens during future public health crises.

## 4.2 Possible Future Improvements

There is significant room for improvement in this project. In this section, we offer suggestions for improving the game. One approach to achieving more realistic predictions could be to incorporate machine learning models, particularly those designed for processing sequential data like Long Short-Term Memory (LSTM) [45]. Comparing players' performance to real data after completing each game round could be implemented to provide players with feedback on their performance. This would be easier to achieve with higher prediction accuracy. Additionally, alternative visualization techniques could be explored to improve the interface and make the overlapping situations cleaner, rather than relying on red dots on the China map.

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# 6 Appendix A – Meeting Minutes

## 6.1 Minutes of the 1st Project Meeting

Date: July 10, 2022

Time: 4:30 pm

Place: Zoom Meeting

Present: Prof Ma, Yuanhao and Wenbo

Absent: None

Recorder: Wenbo

1. Approval of minutes

   This was the first formal group meeting, so there were no minutes to approve.

2. Report on progress

   2.1 All team members have done some research on the background, motivation and existing solutions for the project.

2.2 We introduced the background information, two existing solutions and the information about serious game that we have found.

3. Discussion items

3.1 Prof. Ma thought that the motivation is quite clear, but the concept of policy understanding should be more clearly defined: whether it needs citizens to understand the rationale, or need the citizens to do something else.

3.2 Prof Ma suggested that we need to indicate how serious game can solve our gaps. We then introduced this part to her. She thought it was OK.

4. Goals for the coming weeks

All members will begin to think about the design of our game, including the objectives and our design requirements.

5. Meeting adjournment and next meeting

The meeting was adjourned at 5:00 pm.

The next meeting will be at 4:30 pm on August 1st in Zoom.

## 6.2 Minutes of the 2nd Project Meeting

Date: August 1, 2022

Time: 4:30 pm

Place: Zoom Meeting

Present: Prof Ma, Yuanhao and Wenbo

Absent: None

Recorder: Wenbo

1. Approval of minutes

The minutes of the last meeting were approved without amendment.

2. Report on progress

2.1 All team members have come up with some design requirements based on our gap with the existing solutions, and try to complete the design part of the proposal.

2.2 We introduced the design requirements of our game.

3. Discussion items

3.1 Prof Ma suggested that we should include bullet points of to-do lists that are more concrete, such as we will design and develop something, and that we will evaluate our design. She also suggested that we should specify the platform of our game and the targeted people in the design part of the proposal.

3.2 Prof Ma asked whether the policies in our game will be restricted to some specific policies such as lockdown or just some general policies that can control the disease.

3.3 Yuanhao said that we will choose to use all the policies that are related the disease control.

3.4 Prof Ma suggested that we should choose specific policies and mention them in the design part, otherwise our workload will be large. She suggested that we choose some policies such as lockdown to implement as the base line and if we have extra time, we could implement more policies.

3.5 We asked whether we need some references to support our choice of policies.

3.6 Prof Ma said that reasons like these policies are most widely adopted or these policies are most familiar with the city we are living in are enough.

3.7 Prof Ma asked how much freedom we will give to the users. Will we allow customers to choose the population density, the number of hospitals, etc., or we just develop based on real world data.

3.8 We explained that we are going to choose the real data and do not want to give the users a lot of cognitive burden to make the game easy to play.

3.9 Prof Ma pointed out that we should specify the technical aspects of our game, such as how we will build our server, and how to store the game data. She also stated that we should draw the architectures of our game. She said that if we have ideas about the style of our game, the interaction forms that we will include, we could include some drafts in our proposal.

4. Goals for the coming weeks

4.1 All members begin to think about the technical aspects about our game, including the issues mentioned by Prof Ma.

4.2 Wenbo will work on writing the proposal based on the ideas we have discussed.

5. Meeting adjournment and next meeting

The meeting was adjourned at 5:20 pm.

The next meeting will be at 4:30 pm on October 25th via Zoom Meeting.

## 6.3 Minutes of the 3rd Project Meeting

Date: October 25th, 2022

Time: 5 pm

Place: Zoom Meeting

Present: Prof Ma, Yuanhao and Wenbo

Absent: None

Recorder: Yuanhao

1. Approval of minutes

The minutes of the last meeting were approved without amendment.

2. Report on progress

2.1 We discussed and formed the game rules.

2.2 We discussed the design of game scene.

2.3 We used Unity to build the main game scene and achieved the basic functions.

3. Discussion items

3.1 Prof Ma suggested that we should test the prediction models for infection, citizen satisfaction, etc.

3.2 Prof Ma suggested that we should make the choice of visualization fit the style of game.

3.3 Prof Ma suggested that we should provide basic information about the city and other reference/benchmark information.

3.4 Prof Ma suggested that we should Connect the qualitative information with the quantitative information.

4. Goals for the coming weeks

4.1 Add functions to the game scene, such as visualizing the trend of COVID cases, death cases and citizen satisfaction, and creating filters to let user see those data of a specific city.

4.2 Build other major scenes such as the scene to select policies and develop the functions on Unity.

5. Meeting adjournment and next meeting

The meeting was adjourned at 5:20 pm.

The next meeting will be at 5:30 pm on November 22nd via Zoom Meeting.

## 6.4 Minutes of the 4th Project Meeting

Date: November 22nd, 2022

Time: 5:30 pm

Place: Zoom Meeting

Present: Prof Ma, Yuanhao and Wenbo

Absent: None

Recorder: Yuanhao

1. Approval of minutes

   The minutes of the last meeting were approved without amendment.

2. Report on progress

   2.1 We designed the visualization on the left side of the game scene.

   2.2 We provided basic information about each city and the filtering function to display the data of each city.

   2.3 We decided the policy scheme we would implement in the game and find an index summarizing its effect.

   2.4 We linked the qualitative data with quantitative data.

   2.5 We adjusted the style of the user interface so that it fits better into the theme of the game.

3. Discussion items

3.1 Prof Ma suggested that we should consider better visualization design (avoid dual axis, better contrast, etc.)

3.2 Prof Ma suggested that we should possibly add GDP-related factors into the interface if GDP is considered in the backend model.

3.3 Prof Ma suggested that the backend prediction should clearly reflect the relationship between lockdown policy/stringent index and the change in COVID cases, death, and GDP.

3.4 For satisfaction prediction, Prof Ma suggested that we should consider abstracting the values into higher level concepts to map related socioeconomics model .

4. Goals for the coming weeks

4.1 Add the policy selection components to the game scene and fit the frontend data into the storyline.

4.2 Build an appropriate model to predict the data (e.g., infection, death).

5. Meeting adjournment and next meeting

The meeting was adjourned at 5:50 pm.

The next meeting will be at 1:30 pm on January 6th via Zoom Meeting.

## 6.5 Minutes of the 5th Project Meeting

Date: January 6th, 2023

Time: 1:30 pm

Place: Zoom Meeting

Present: Prof Ma, Yuanhao and Wenbo

Absent: None

Recorder: Yuanhao

1. Approval of minutes

The minutes of the last meeting were approved without amendment.

2. Report on progress

2.1 We improved the visualization by using two separate line charts instead of one with dual axis.

2.2 We implemented the interaction panel to let players selecting the policy stringency for each city.

2.3 We completed the basic logic of the game, including determining ending conditions, showing main menu and end scene, and showing popup warnings.

2.4 We implemented part of the animations so that changes on the scene are more fluent.

3. Discussion items

3.1 Prof Ma suggested that we should control the policy adjustment frequency and magnitude, possibly linking these factors to satisfaction.

3.2 Prof Ma suggested that we should highlight the selected city and provide some basic background info about the city if possible.

3.3 Prof Ma suggested that we should provide explanations of the policy indices and values.

3.4 Prof Ma suggested that we should provide a summary of performance during and upon the termination of the game.

4. Goals for the coming weeks

4.1 Develop the model to do data predicting and integrate it into the front end.

4.1 Improve the storyline, including adding more contents in the news and social media part, adjusting the parameters (e.g. terminating conditions) in the game.

4.3 Continue to polish the game by designing animations for the remaining part of the game.

5. Meeting adjournment and next meeting

The meeting was adjourned at 1:50 pm.

The next meeting will be at 5:30 pm on February 9nd via Zoom Meeting.

# 7 Appendix B - Questionnaire

The questions are generally 7-point Likert scale style unless otherwise specified.

1 = strongly disagree

7 = strongly agree

### *Background survey*

- Your contact method
    - Email (string)
    - Others, please specify (string)
- Your age (integer)
- Your gender
    - Male
    - Female
    - Prefer not to answer / Non-binary

### *Part 1 COVID PTSD symptoms*

Please indicate your agreement level with the following statements:

- I have had upsetting dreams that replay part of the COVID-19 policy-related experience or are clearly related to it.
- I have had powerful images or memories that sometimes come into my mind in which I feel the COVID-19 policy-related experience is happening again in the here and now.
- I have avoided internal reminders of the COVID-19 policy-related experience (e.g. thoughts, feeling, or physical sensations)

- I have avoided external reminders of the COVID-19 policy-related experience (e.g. people, places, conversations, objects, activities, or situations)
- I have been "super-alert", watchful, or on guard due to the COVID-19 policy-related experience.

### *Part 2 COVID-19 sleep disturbances*

Please indicate your agreement level with the following statements:

- I have difficulty falling asleep (< 30 min) due to the COVID-19 policy-related experience.
- I have difficulty sleeping through the night due to the COVID-19 policy-related experience.
- I have early morning awakening due to the COVID-19 policy-related experience.

### *Part 3 COVID-19 substance use*

Please indicate your agreement level with the following statements:

- I have consumed substantially more alcohol than usual due to the COVID-19 policy-related experience.

- I have consumed considerably more drugs (e.g. tranquilizers, sleeping pills or stimulants) than usual due to the COVID-19 policy-related experience.
- I have smoked considerably more cigarettes than usual due to the COVID-19 policy-related experience.
- I have felt a strong desire to consume addictive substances (alcohol, cigarettes, drugs) due to the COVID-19 policy-related experience.
- I have not been able to control my use of addictive substances (alcohol, cigarettes, drugs) due to the COVID-19 policy-related experience.

*Part 4 COVID-19 political and institutional trust*

Please indicate your agreement level with the following statements:

- I have had the feeling that the political leadership was standing up for me.
- I have perceived democracy as an effective form of government.
- I have had the feeling that public institutions (e.g. police, judiciary) can be relied upon.
- I have had the feeling that news and reports on the COVID-19 pandemic are being deliberately withheld.

- I have perceived politicians as trustworthy.

### *Part 5 COVID-19 conspiracy beliefs*

Please indicate your agreement level with the following statements:

- I have had the feeling that false reports or untruths about the COVID-19 pandemic are being deliberately disseminated on public broadcasting (e.g. radio and television stations).
- I have had the belief that there are alternative or secret explanations for current events.
- I have had the belief that there is a relation between what is happening and the production and testing of biological weapons.
- I have had the belief that what is happening here is the effect of a struggle or competition between different superpowers.
- I have had the belief that this infection serves to deliberately reduce the world population, since there are no longer enough resources for everyone.

# 8 Appendix C – Project Planning

## 8.1 Distribution of Work

| Task | Yuanhao | Wenbo |
|---|---|---|
| Do the survey of COVID-19 policy related problems | ● | ○ |
| Analyze existing solutions | ○ | ● |
| Design the storyline of the game | ● | ○ |
| Collect related COVID-19 data to be used | ● | ○ |
| Build the model for data prediction | ● | ○ |
| Find appropriate data visualization methods | ○ | ● |
| Develop the main game scene | ○ | ● |
| Develop the other parts of the UI | ○ | ● |
| Develop the main game loop | ○ | ● |
| Develop the update rules for qualitative data | ● | ○ |
| Test the functioning of user interfaces | ○ | ● |
| Perform integration testing | ○ | ● |
| Perform evaluation on the effectiveness of the game | ● | ○ |
| Write the reports | ○ | ● |
| Prepare for the presentation | ● | ○ |
| Design the project poster | ● | ○ |

● Leader ○ Assistant

## 8.2 GANTT Chart

| Task | July | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr |
|---|---|---|---|---|---|---|---|---|---|---|
| Do the survey of related problems | | | | | | | | | | |
| Analyze existing solutions | | | | | | | | | | |
| Design the storyline of the game | | | | | | | | | | |
| Collect related COVID-19 data to be used | | | | | | | | | | |
| Build the model for data prediction | | | | | | | | | | |
| Find appropriate data visualization methods | | | | | | | | | | |
| Develop the main game scene | | | | | | | | | | |
| Develop the other parts of the UI | | | | | | | | | | |
| Develop the main game loop | | | | | | | | | | |
| Develop the update rules for qualitative data | | | | | | | | | | |
| Test the functioning of user interfaces | | | | | | | | | | |
| Perform integration testing | | | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Perform evaluation on the effectiveness | | | | | | | | | | |
| Write the proposal | | | | | | | | | | |
| Write the monthly reports | | | | | | | | | | |
| Write the progress report | | | | | | | | | | |
| Write the final report | | | | | | | | | | |
| Prepare for the presentation | | | | | | | | | | |
| Design the project poster | | | | | | | | | | |

# 9 Appendix D - Required Hardware & Software

## 9.1 Hardware

PC for development and testing: PC with MS Windows 10 or later

## 9.2 Software

Unity [41]: Platform for game development

C# [42]: Programming language for game development