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## Special Issue on Games for Education Preface

**Maria Mercedes T. Rodrigo**

As a student, my literature and reading teachers would tell us how literature was a mirror of society. It captured and conveyed current issues, societal concerns, and the human experience. Each story told us something about ourselves, about our world, and how this world operates. The same can be said for games. Games are, to a great extent, literature made interactive. Each game captures and conveys current issues, societal concerns, and the human experience. Each game tells us something about ourselves, about our world, and how this world operates. In addition, games enable us to make choices, enact alternative lives, and live out consequences in a safe space. We devote this special issue to a suite of such games. The games in this issue were intended to package an educational message in a fun, entertaining, and highly interactive experience.

All of these games were created during the height of the COVID-19 pandemic and in the midst of growing societal awareness of social media's influence over democracy. We therefore begin this special issue with the game of Luis Sebastian P. Dela Vega IV and Trey Jaymie S. Antonio entitled *Missed Information: A Video Game Designed to Teach Methods of Spotting Fake News in Social Media* (<https://tinyurl.com/MI2022Game>). It is a puzzle simulation game that educates its players on methods by which to spot fake news on social media. The aim is for the player to come out of the experience knowing what fake news is and how to identify them, and to be able to apply this knowledge to their everyday life.

Kimberly Anne Chua and Joshua Graham Son focus their attention on life during the pandemic with their game *Locked Down: A Video Game About the Struggle of the Poor in the Philippines During a Pandemic* (<https://coldheart50.itch.io/locked-down>). *Locked Down* is a 3D stealth game that aims to increase the player's empathy towards the poor and lessen their tendency to stereotype the police. It does this by allowing the player to experience (through perspective-taking) the difficulties faced by both parties during a pandemic.

Among the heroes of the pandemic were the delivery riders. They were the frontliners who, despite difficult working conditions, made sure we got our food, medication, and other essentials as we sheltered in place. Sadly, these riders are victims of inauthentic consumer behavior. To help us understand the work and life of a delivery rider, Alysha C. Columbres, Joaquin D. Espino, and Martin David J. Puache give us *KaChow! Food Delivery Service A Virtual Reality Delivery Simulation Game* ([tinyurl.com/4cc2fyf3](https://tinyurl.com/4cc2fyf3))

Shining a light on the dangers of smoking, Cidney P. Ciacho and Neil Patrick L. delos Reyes give us *Toxscreen: A Game for Prevention of Substance Abuse* ([tinyurl.com/5n78uxyv](https://tinyurl.com/5n78uxyv)). This is a tower defense game that makes use of cognitive behavioral game design methods to inform players about the consequences of excessive smoking.

Hannah Isabel D. Binondo and Sylvane Q. Sumingit address another issue of concern: mental health. *Hot-air Penguin Pair: A Breath-controlled Video Game to Lower Stress Levels of College Students* (<https://j4gw4r.itch.io/hot-air-penguin-pair>), a third person side-scrolling adventure experience designed with the goal of reducing players' stress levels by incorporating the 4-2-4 breathing technique. The game's innovation is that it literally uses breath as the main input mechanic of the game.

With an eye towards climate change and the protection of our oceans, Anton Ralph F. Valenzuela and Rom Cristian Q. Enriquez give us Reef Warden: A Game About Reef Protection and Preservation. In this strategy game, players act as wardens of Tubbataha Reefes Natural Park and World Heritage Site. They check on the reef, monitor tourist activities, and arrest illegal fishermen.

Gerick Jeremiah Niño N. Go and Angela Nicole C. Yap express their concern for our fish stocks with the game AquaFarm Ace: A Game on the Intensive Aquaculture Process of Oreochromis niloticus (<https://play.unity.com/mg/other/aquafarm-ace-v6>). AquaFarm Ace is 2D Time-Management simulation game on the intensive aquaculture process of the Nile tilapia. The player takes the role of an aquaculturist and goes through the various stages of raising the fish until they are ready for consumption.

The paper of Carl Alden B. Go, Margarita Juliana Perez, and Jonathan William Talbot entitled WHIMCEE: A Study on the Migration of WHIMC from Minecraft Java Edition to Education Edition describes the process of converting worlds created in Minecraft Java Edition to Education Edition. WHIMC or What-If Hypothetical Implementation in Minecraft is a set of alternate versions of Earth, e.g. Earth with no moon, Earth with a colder sun, etc., created in Java Edition by a team at the University of Illinois Urbana Champaign. Go and colleagues recreated these worlds in Education Edition to make them more accessible to Microsoft subscribers with free access to this version of Minecraft.

The team of Dan Mark Restoles, Catherine Golles, and Jared John Javillo take us back in time with Bala: Stealth First-Person Action Game Depicting the Philippine Revolution of 1896 (<https://dmdrestoles.itch.io/bala>). Bala is a historically-inspired video game which depicts the context, uniforms, and weapons used by the Philippine Revolutionary Army. It gives players key historical information about the battle and the revolution.

This special edition ends with the paper of Butch Adrian A. Castro, Jed Laszlo O. Jocson, Jesus Alvaro C. Pato entitled In-Between Frames: An Animation Adventure A Modified 2D Action Metroidvania About the Principles of Animation (<https://nobadword.itch.io/in-between-frames>). This 2D modified action metroidvania uses animation as its core mechanic. The player has to collect keyframes and arrange them to create their movement and combat animations.

By assembling this special issue, we hope to bring attention to these games and others like them, games that try to use the medium as a platform to comment on past and present, games that invite players to dream of alternate, better futures that we can create by our actions today.

For making this special issue possible, I thank all our authors, the committees that reviewed their work, and the Ateneo Laboratory for the Learning Sciences. I especially thank Dr. Jenilyn A. Casano, Mr. Walfrido David Diy, and Mr. Jonathan Casano who have been my constant collaborators and co-mentors in guiding the development of these works. Finally, I thank our additional external reviewers Dr. Josephine Dela Cruz and Dr. Gerry Genove of St. Louis University, Baguio; Ms. Celesamae Vicente of Mindanao State University Iligan Institute of Technology; Dr. Angie Ceniza of the University of San Carlos, Cebu; and Dr. Maureen Villamor of the University of Southeastern Philippines, Davao.

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# Missed Information

## A Video Game Designed to Teach Methods of Spotting Fake News in Social Media

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### ABSTRACT

The goal of this project is to develop a video game that educates its players on what fake news is, and teaches them the methods to identify articles in social media that are verifiably false. Missed Information is a puzzle simulation game where the player takes on the role of a fact-checker hired by a social media company. They are presented with details about fake news such as its definitions and the potential origins of different pieces of news. They will also learn the methods for spotting fake news and the aspects of news articles that can be scrutinized to determine their validity. As the game goes on, they are introduced to more methods of spotting fake news. The aim is for the player to come out of the experience knowing what fake news is and how to identify them, and to be able to apply this knowledge to their everyday life. This is a continuation of a project that began in 2020 by Luis IV de la Vega and Matthew Aguilar. This iteration of the project aims to address the feedback and recommendations given in the previous year's project and further deepen the mechanics of the game.

### CCS CONCEPTS

• Computer graphics → Applications → Computer uses in education • Personal computing → Games

### KEYWORDS

Fake News, Misinformation, Puzzle Games, Puzzle Simulation Games, Educational Games

### ACM Reference format:

Luis Sebastian IV P. de la Vega and Trey Jaymie S. Antonio. 2022. Missed Information: A Video Game Designed to Teach Methods of Spotting Fake News in Social Media. In *Philippine Information Technology Journal (PITJ2022)*. City of Manila, Philippines, 15 pages.

## 1 Introduction

### 1.1 Context of the Study

Fake news has been a buzzword in the global social consciousness since the 2016 US Presidential elections, particularly on social media platforms such as Twitter and Facebook, and has become a topic of interest across multiple disciplines [1]. The term has been used by all people of varying political and social backgrounds, describing it in multiple ways and in many different contexts. “Fake news” has been used so much that its definition can vary even among scholarly articles [2]. For the purposes of this game, the term “fake news” is described as any article that is undeniably false and could deceive readers into believing it, intentionally or not [3].

The aim of the game is to be a puzzle simulation game that simulates a social media app filled with different kinds of news articles that would teach the players how to differentiate fake news from legitimate news using eight different methods. The game will introduce methods for spotting fake news and provide more information on fake news itself. This study is a continuation of a project that began in 2020 [16]. In this iteration of the project, the aim is to address the feedback that was gained from the results of testing the game then and the recommendations that have been brought up because of it. The further aim of this iteration of the project is to address the shortcomings of the previous build of this game, specifically that of pacing and lack of feedback from the game, and to further polish current aspects of the game, such as the UI.

### 1.2 Research Objectives

Being that this is a continuation of a previous iteration [16], the general objectives are similar. The researchers aim to further develop the puzzle simulation game that simulates a social media app filled with different kinds of news articles that would teach the players how to differentiate fake news from legitimate news using eight different methods. The game will introduce methods for spotting fake news and provide more information on fake news itself. Along with this, another objective would be to address the feedback that was gained in the previous iteration of this study.

### 1.3 Research Questions

Being that this is a continuation of a previous iteration [16], the research questions are the same as that of the previous iteration. This study aims to answer the following questions: (1) How does one design a game that teaches players multiple methods of spotting fake news? (1a) What elements of gameplay can be employed in a puzzle simulation game to make players remember how to spot fake news? (1b) How can methods of spotting fake news be represented as game mechanics? (2) How effective will the game be in teaching players methods for spotting fake news?

### 1.4 Scope and Limitations

The main target audience of the game itself will be Filipinos who use social media on a daily basis, specifically those ages 18-34, so the simulated articles will be similar to how prominent news sources in the Philippines would feature their articles and stories on Facebook. Along with this, being that the game is meant to educate, another target audience would be high school students. The game could be used as an educational tool and supplement in helping these students understand fake news more and learn more about media literacy.

The main goal of the game is to properly simulate news articles as they would be shown on social media. Since Facebook has practically been a modern daily news source, the simulated social media will be influenced by how Facebook looks and feels. How these simulated articles will be written will be based on the advice of a subject matter expert and through further research on how these news sites frame these headlines. To ensure consistency in the game's difficulty and progression system, variety in articles will be limited. The game will also only contain eight levels, to make sure that the pace at which new methods are being taught can be controlled. The game will be 2D and be built using Unity version 2021.1.14f1, and will be able to run on any browser itch.io. Alternatively, the game can be downloaded and run on Windows OS and MacOS.

### 1.5 Significance of the Study

Although fake news has been a topic on people's minds in recent years, there is still a difference between knowing its existence and being able to distinguish if a news article is true or not. People may understand that misinformation and disinformation exist, and this may skew their awareness of the prevalence of fake news in social media, regardless of whether or not they themselves have encountered it. In a September 2018 survey conducted by Pulse Asia, a public opinion polling body in the Philippines, 88% of Filipino

respondents who have social media access are aware of fake news on these platforms, with 79% of them even saying that it is widespread [5]. However, in terms of actually being able to distinguish between factual and false information, there is no significant data available. There is, however, research on how social media has been used as a weapon for political gain, using disinformation campaigns to push their own agendas during the 2016 presidential elections [6]. The research shows that click farms, fake news, and troll armies were used by different political personalities in an attempt to spread false information across social media to Filipinos [6].

These disinformation campaigns can affect an individual's perspective on several matters. It can affect a person's trust and perception of others, and influence their opinion of socio-political issues. People who are heavily exposed to fake news may even trust fake news sources more than legitimate ones [3]. Fake news has already gained the attention of major internet companies such as Facebook and Google, who are actively taking measures to reduce the prevalence of fake news on their platforms [3]. However, the way fake news campaigns thrive is that they only target specific circles, not the general public. They concentrate their efforts on a subpopulation because it would be easier to influence them instead of aiming for the larger public [7]. This makes spotting a fake article a paramount skill individuals must learn, as they may never know if they are part of the target audience of a disinformation campaign.

## 2 Review of Related Literature

The goal of this study is to create a game that will be able to teach the methods of spotting fake news and to provide more information regarding its nature. The game should be able to effectively teach the players about misinformation and disinformation through its features and mechanics. The goal of this chapter is to review related concepts and works that are indicative of the state of the art. This chapter would look into the Review of Related Literature present in the previous iteration of this project, which focused on two different topics: learning through games and fake news. Games that are already teaching about fake news will also be looked into.

### 2.1 Previous iteration of Missed Information

The paper of Aguilar and de la Vega [16] provides an overview of the literature that served as a basis for this paper. It discusses the use of video games as vehicles for learning [10][11], methods of spotting fake news [12][13][14], and an example of a game that addressed this same issue [15]. From this review, it was surmised that the

end product that this project should have is a game that would simulate a social media site that would host fake news and teach the players methods for spotting fake news. The game this project would create should be able to motivate and engage the player in terms of learning more about fake news, along with being able to use the skills they learned in-game on a real-world social media wall. After playing it for a significant amount of time, the player would hopefully gain knowledge through cognitive learning, that being the methods, and also relational learning, that being of a fact-checker even outside the simulated environment. The game would essentially gamify the methods of fake news, mostly being pulled from the How to Spot Fake News article which supplies eight different methods of determining misinformation [14].

Along with the review of related literature present in the previous iteration of the study, it would also be good to note the issues and recommendations that stemmed from the testing done before.

An issue respondents claimed to have encountered while playing the game is that they did not receive an explanation as to why they flagged an article wrong. In the previous build of the game, it would let players recheck the articles after each stage and where they got them wrong, but the game did not provide them adequate information on why these articles are marked as fake. Due to the educational nature of the game, there is merit in giving players more detailed justifications as to why certain articles are deemed fake.

Another issue from the previous iteration is the lack of tutorials. The only form of a proper tutorial the previous build provides is a help button, which some players can easily miss. To address this, the game should dedicate a section at the start to teach the player the basic functions and controls of the game. This is so that new players will not be as lost whenever they play the game.

Lastly, feedback from last year stated the one shortcoming of the game is its pacing. In this regard, the problem with the pacing of the game is that there are technically no breaks in between reading articles. Since after finishing a level the game simply goes to the next one, the player will be reading multiple articles nonstop, which can be tiring to a point. The game in this iteration should then have some sort of break in between reading intensive levels.

## 2.1 Factitious

Factitious is a puzzle game created by the AU Game Lab which was made to help players learn how to determine if a news story is misinformation or not [15]. The game is divided into levels of varying difficulty. In each level, the player will be given a real news article headline, a snippet of

the article, a placeholder image related to the article, and its source to determine if it's legitimate or not. It should also be noted that all the articles and sources Factitious uses are that come from the real world. The developers of the game used articles that they found online and condensed them for the sake of the game [15].

The player will only progress the level once they have correctly determined the number of articles. Whether the player answers wrong or not, the game will still explain the features that show the article's legitimacy or lack thereof. The only limitation of the game is that it focuses mostly on two factors when spotting fake news: content and sources [15]. As of 2020, the developers, AU Game Lab, released a version of Factitious where all the articles are related to COVID-19 to help to combat the rise of fake news in regards to the global pandemic [17].

The gameplay loop of Missed Information will be similar to that of Factitious, but more complex to include more methods. The player will also have to explain why they determined an article to be fake or not, as a way to engage with them more and to motivate more critical thinking.

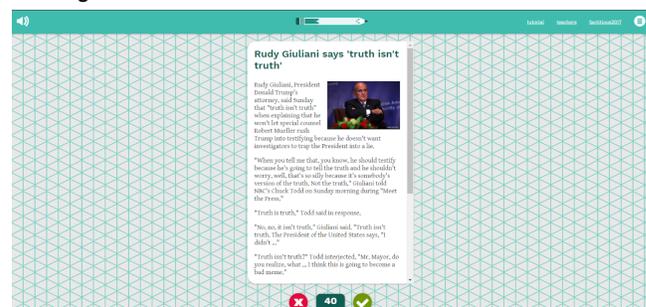


Figure 1: News Article as shown in Factitious

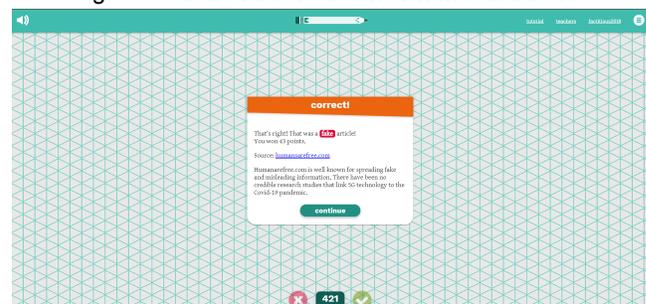


Figure 2: Result screen after determining article legitimacy in Factitious 2020

## 2.2 Bad News

Bad News is a decision-based, simulation game developed in a collaboration between the University of Cambridge's Social Decision-Making Lab and the media agency DROG wherein players act as fake news producers utilizing different techniques of deception to gain a following in social

media [18]. By providing players a hands-on experience on fake news production, the game aims to increase players' awareness of indicators of fake news, and develop within players an immunity towards such practices. Later in 2021, a version of Bad News called GO VIRAL was released wherein the topics discussed were related to the public's response to COVID-19 related myths and anti-vaccine propaganda [19].

The objective of the game is to increase the player's following and credibility on social media, and this is tracked through the follower count and credibility score. Whether the follower count and credibility score increase or decrease depends on the player choosing the right decisions in applying the deception techniques. Through this reward and punishment system, the game reinforces player behavior to remember and choose actions that lead to the deception techniques.

Due to the educational nature of Missed Information, there will be no Game Over. Instead, similar to how the credibility score tracks the player's performance, Missed Information will implement a reputation score that is affected by the player's accuracy in flagging the different articles. This will also serve as the narrative objective of the game, wherein players are building credibility for their organization, Illuminant.

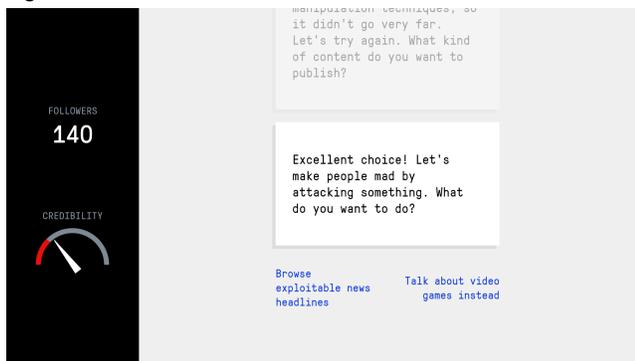


Figure 3: Gameplay from Bad News



Figure 4: Game over screen due to low credibility score

## 2.3 Papers, Please

Papers, Please is a puzzle simulation game created by Lucas Pope. The game takes place in the fictional socialist country of Arstotzka. The player then takes on the role of an immigration officer, working at a checkpoint on the direct border of the country [20].

The player must review all the passports of every person that comes through the checkpoint, to see if their documents are legitimate. If the person who wishes to pass through has all the correct documents, the player should approve of their passage. If there is even one mistake, the player should have to deny them entry. At the end of the day, the player is paid based on how much and how well they did, and they can use their money on their family. As the game progresses, more rules and more documents are added for the player to check, and with the pressure of the time limit and the need to provide for the player's family, the game becomes more difficult [20].

In a similar sense, Missed Information will have similar gameplay to Paper's Please. The player will have to check on a document and either approve or disapprove of its legitimacy or lack thereof. However, as the game goes on, more complications are added for the player to juggle, challenging to balance all the things they've learned from the previous levels. Based on how well the player is doing, they will be awarded points per level, money in the case of Papers, Please, and reputation in the case of Missed Information. Due to the educational nature of Missed Information though, there will be no hard time pressure, but a time bonus will still be there should a player wish to optionally challenge themselves.



Figure 5: Early level gameplay from Papers, Please



Figure 6: **Gameplay from Papers, Please after a few more levels**

### 3 Methodology

#### 3.1 Game Design Elements

The paper of Aguilar and de la Vega [16] analyzed seven core elements of an educational game [8][9]. It discusses how these elements should be taken into consideration when designing the game, and use them as guidelines in achieving the goal of the game which is to teach methods of spotting fake news. In summary, the end product will be a stage-by-stage puzzle game that has a scoring system. Each stage will introduce a new method so that the game will have a steady increase in challenge as it goes on, and also as to not shock the player with information overload. The puzzles in each stage will also be randomized, to add a sense of uncertainty to the game. Each stage will have a number of articles for the player to go through so that they will be repeatedly analyzing them, and hopefully hone their usage of the methods the game is teaching them.

The game will also be tracking how well the player is through a point system. Here the player will be able to quantify how well they are doing in the game. To add to the scoring system, the build from the previous iteration of this project did not necessarily incentivize the player in gaining more points. At most, the player will be able to see an uptick in their scores, but having more points will not do much within the game. Another element that should also be considered in this iteration of the project is to incentivize the player in getting more points. This can be done either by having the game react to the player's score count, or use the points as a sort of currency to be traded in for rewards.

#### 3.2 Game Development

##### 3.2.1 Puzzle Population

In order to include a replayability value to the game to incentivize players to improve their ability at the puzzles, there will need to be a template for puzzles to follow that will

allow the game to be read, stored as a collection of data. These will include pictures, text, goal values, and the underlying values for the scoring system.

##### 3.2.2 Art Assets

Because the nature of the game follows the design of actual web articles, the art and graphics do not require a lot of personalization to the game. There are likely art assets that are either easily available online or can be created by the proponents that will suffice for the game. There will be a need to create a detailed plan first of the mechanics of the game and the underlying UI before the complete overview of the art assets required is foreseen. If there are any gaps in this field, the researchers will source material from available artists.

#### 3.3 Feedback from previous iteration

Considering the feedback from the previous iteration of the game [16], which was outlined in the Review of Related Literature section, this iteration should address the shortcomings present previously.

One shortcoming of the game was the lack of tutorials. To address this, the game should dedicate the start of the game to a tutorial stage. This tutorial stage should be able to teach the players all the basic functions of the game before they properly get into the game loop proper. It should not just be a list of all the buttons and functions the game will show, but the tutorial should mimic a regular stage so that players will be able to try out the functions of the game instead of just reading about it.

To address the feedback on the pacing of the game and the lack of in-game explanations for wrongly flagged articles, a new feature in the game should be implemented. This feature will be the hub world, which is meant as a break for players in between the reading intensive levels of the game. This hub world will have features such as the feedback system, that would tell the player what they got wrong or right, and the reasoning behind it, as well as a codex, which would feature supplementary information about fake news not directly addressed by the game. This supplementary information will primarily come from UNESCO handbook Journalism, 'Fake News' & Disinformation [12][13].

#### 3.4 Testing

Once a playable build is available, the game will go through a testing phase. The main target audience will be Filipino adults aged 18-34, as this is the age demographic of people that use social media on a daily basis, which is also the target audience of the game itself. Participants will be recruited through social media sites like Facebook and Messenger. The whole process will be done

asynchronously, and those who said they were interested will be emailed the step-by-step instructions of the testing process, the surveys they need to complete, and a playable build of the game. The playtesting will serve two purposes in this case: to see the reactions of players to the gameplay and mechanics of the game, and to see the effectiveness of the game in teaching the methods of spotting fake news. There will be two parts to the testing process: playtesting the game itself and a feedback form

#### 3.4.1 Feedback Form

After finishing their playtest of the game, the participants will then fill up a feedback form. This form will ask the participants about their experiences playing the game. In terms of the experience, the players will be asked how they feel about the gameplay and the graphics of the current build. In terms of gameplay, they will be asked about their ease of play and the enjoyability of the game. In terms of graphics, they will be asked about the clarity and readability of the UI and the design of the assets within the game.

## 4 Results

### 4.1 The Game

#### 4.1.1 Story

The game is set in the fictional country of Berladel. The year is 2016 and an election is about to take place. Two names have been at the forefront of the social consciousness due to the election. Fernando Paloma, a tough-talking, hard-fisted figure who is aiming for the seat of Presidency, and Julina Dominguez, a more traditional politician running for Vice President. Due to the polarizing nature of the election campaigns, misinformation has been spread rampant online, especially on Berladel's most popular local social media site.

The player is an employee for a relatively new fact-checking organization called Illuminant. Illuminant has recently partnered up with a social media company called Socialite after the company has been taking serious repercussions from the amount of misinformation being hosted on their networking site. The company has decided to take steps to salvage its reputation and prevent future congressional subpoenas by combating fake news. One of these steps is partnering with a highly accredited fact-checking group, and the player is assigned by Illuminant to be part of the Socialite project.

The player will be working with Socialite for 4 years, trying to build the reputation of Illuminant while combating the fake news that plagues the social media site. Throughout the game, the player will also encounter news

articles regarding the happenings within Berladel. These stories may range from a dengue vaccine controversy the government is facing, to an insurgent attack in one of the regions of Berladel. Almost all of them have gone viral or have been shared extensively, but not all of them are credible, and after some rounds, they are given some insight into some of the news stories that they approve or disprove.

The game will end in 2019 when a general election will be happening. In this election, the same 2 key players from the last election are now both running for the same position, the seat of the President. Depending on how well the player does in combating misinformation in the previous years, their actions may in fact impact the outcome of the elections.

#### 4.1.2 Gameplay

The game is a 2D space that imitates a desktop where the player is working as a fact-checker. They are given their workstation and browser where they will receive the articles slated for review. Every article will look similar to news websites, with details in them available for the player to see. The players will have the ability to click on details that will open new windows for them to browse through.

For example, they can view the author of an article, and clicking on it will allow them to view a summary of the author that would be provided by a database made by the fact-checking company the player is part of.

##### 4.1.2.1 Rules and Mechanics

The player will have the ability to examine each article they are meant to judge. This includes the headline, content, and also underlying links to the news source and author. The player will undergo eight stages, with each stage including seven puzzles. The player will always have the option to flag an article as either true (green flag) or fake (red flag). Starting from the 2nd level, the red flag option will evolve, in which they must now provide the reason or method used to inspect the fake article. Doing so correctly will grant them additional points. Doing so incorrectly will not grant them points if the article does turn out to be fake, or subtract points if the article turns out to be trustworthy.

Performing mistakes will cost the player's overall score at that stage, and performing mistakes on certain articles will cause adverse effects in the virtual world that will become apparent in later stages and in the outcome of the game. Making mistakes will not make the player lose that stage, as the game has no lost state. Since the game is meant to educate, having a game over state for players who are stuck in a level may discourage them from continuing,

and by proxy learning other methods of spotting fake news. The game will react to a player making mistakes in other ways, however. The social media company Socialite will mention their disappointment in the player's performance through email because having a low reputation score means they are not performing their job competently.

To get players acquainted with the basic features, the game will begin with a tutorial stage. This a new feature for this iteration of the game, as a direct response from feedback previously. The tutorial stage will mimic a normal stage, with the exception of the news articles being replaced with an explanation of how the game works. It will explain the basics of flagging articles, how a level in the game works, and other miscellaneous features that might not be immediately apparent to the player. This tutorial stage will not affect the game in any way and is only meant to teach players basic information about the game's functions. Further features will be explained to the player through the email feature.

#### 4.1.2.2 Gamification of Methods per Stage

The player will go through a total of 8 stages excluding the tutorial stage, with each stage representing a different method to learn. These 8 methods were outlined previously in the FactCheck.org article titled '*How to Spot Fake News.*' Each of the 8 methods will be gamified and is introduced once per level. The player should have encountered all eight methods by the time they reach the end of the game. Each stage will have seven random articles, which the game picks from a pool of pre-selected articles before the level starts. Some articles are forced to appear on a level for the sake of pushing the narrative, while other articles are randomized. Each level also corresponds to a certain year starting from 2016. As the player progresses through the stages, they also progress through the years to give a sense of time passing in the narrative. The levels will also have a time limit bonus, wherein players who are able to finish the stage within the time limit will be given bonus points. Players who are unable to finish within the timer will not be punished, other than the loss of potential points.

In each stage, the player will be given details about their new method, and an example of a fake and a real article. The first fake article they review on each stage will be an article they flag using the method just introduced. For the first two stages, all the fake articles use the respective methods. After that, subsequent articles can use any of the methods that have been introduced before. The player is given one article at a time to review. There is no hard deadline on how long they can take to review these articles. In the first stage, the game introduces Considering the Source. The articles include a button which when pressed will show the player the about us description of the site.

They are also introduced to the "red flag" and "green flag" buttons, which they can use to either lock the article out of circulation on the social media site or let it slide.

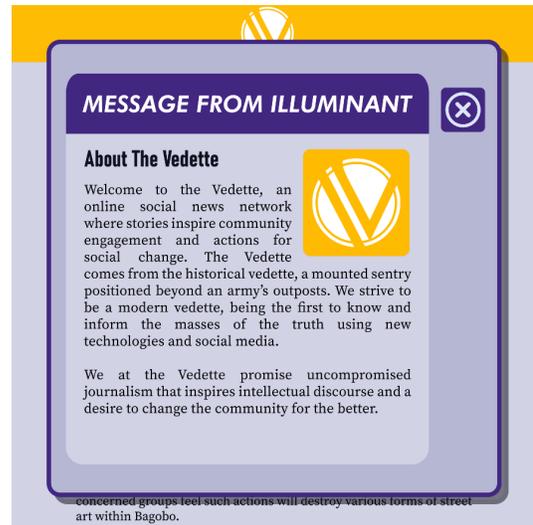


Figure 7: Example of a Source

In the second stage, Check the Author. Similar to how in the first stage there was a button on the about page of the source, a new button will be introduced that will showcase the description of the author of the article. The red flag will also be updated with a new feature. This involves the player flagging articles and giving reasons behind them. At this stage, they can only red flag from the current list of methods, which is flagging the article as being the following: Non-Credible Source and Non-Credible Author. It is important to update the red flag because it is at this point that the players will be using a variety of methods, as opposed to the first stage where the only method they needed was Considering the Source.

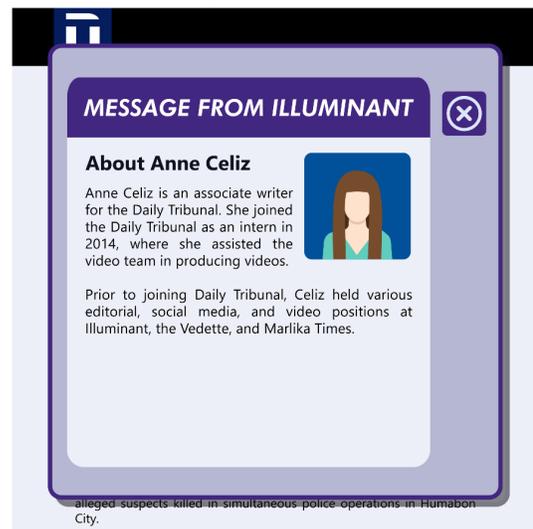


Figure 8: Example of an Author

In the third stage, the game introduces Consult the Experts. Compared to the other methods, this one is different, as it is instead introduced as a “Hint” option. Players get 1 hint they can use at each stage, however, through the reputation system the players may be able to increase their maximum amount of hints to 4. Every article has an attached hint to it leading them to what method they should look out for. The number of hints players have refreshes every stage. This means that if a player exits a stage without any more hints, they will regain their maximum amount of hints in the next level.

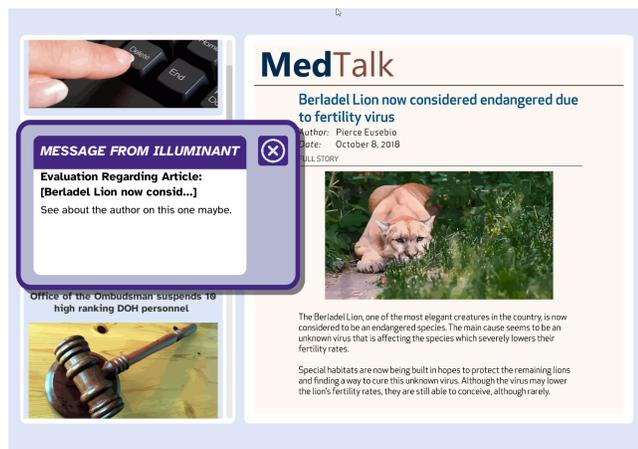


Figure 9: Example of a hint for an article

In the fourth stage, the game introduces Reading Beyond the Headlines. Here, the player still has access to the article itself, but it will be important for them to actually read the article body to see if the headline is accurate. Another method is also added to the list for red flagging: Misleading Headline.

There is also a hidden feature related to the Misleading Headline feature. Since articles with misleading headlines are always linked to the same group of authors, the articles could also be flagged as Non-Credible Author and be given the same amount of points as a correct answer. This will never be stated to the players in-game but will reward players who are able to notice the pattern.

In the fifth stage, the game introduces ‘Is it a Joke?’, where articles now include satirical websites, articles, and headlines. This is different from the misinformation articles, as satire websites will have a more comedic approach to their writing. Satire is also an added option in the red flag button.

In the sixth stage, the game introduces Check the Date. Each stage of the game is in a certain year in-game. Two stages will represent one year, so odd-numbered stages are in the first half of the year, while even-numbered

stages are in the latter half. For example, the game starts in 2016, so stage 1 will be from January 2016 to June 2016, and stage 2 will be from July 2016 to December 2016. Articles that are not in the same time frame as the level should be flagged. Here, the game introduces more red flags: Outdated Article.

In the seventh stage, the game introduces Checking Personal Biases. Here there will be no new flags or specific tools to watch out for, however, the articles introduced will start getting into more polarizing topics within the narrative of the game. There is no objective way of teaching how to check for bias because there is no way of knowing what the player would believe and prefer, however, there is value in teaching it in the game somehow. Checking Bias will not be an option for red-flagging since there is no way of showing this option objectively.

In the eighth and final stage, the game introduces Supporting Sources. This is included last because it adds another layer to the game. Here, not only does the player have to vet the article linked in the social media site, but the articles linked with that article as well. All articles that appear at this level will have a single supporting article associated with them. The players will then have to analyze the new supporting article under the same scrutiny as the regular articles, as fake support will also mean a fake article. The final red flag option, Fake Supporting Article, will also be added.

#### 4.1.2.3 News Articles

Each stage will have a list of articles and their respective headlines on the left half of the screen, and the player will have the option to inspect any of them, giving them access to a screen of the article on the right half of the screen. Every article in the game contains certain information and characteristics that aid the player in determining whether it is fake or not. Every article is published by a news source, the logo of which can be seen at the upper portion of the article. The article also contains the name of the fictional author who wrote it. Both the source and the author can be inspected by the player should they choose so. The article also has a headline and an accompanying picture, both of which the player will have seen before inspecting their chosen article. The pictures are all stylized images that originate from Creative Commons. The article will also showcase its date and time of publication. Lastly, the article also showcases a quick summary of the article itself.

There are five types of articles that are found in the game. True Articles are articles that are showing the truth within the fiction of the game. Some of these True Articles are made for narrative purposes, some are meant to inform the player more about the new method introduced in the level, while others are miscellaneous true articles whose

main purpose is to increase and diversify the puzzle population.

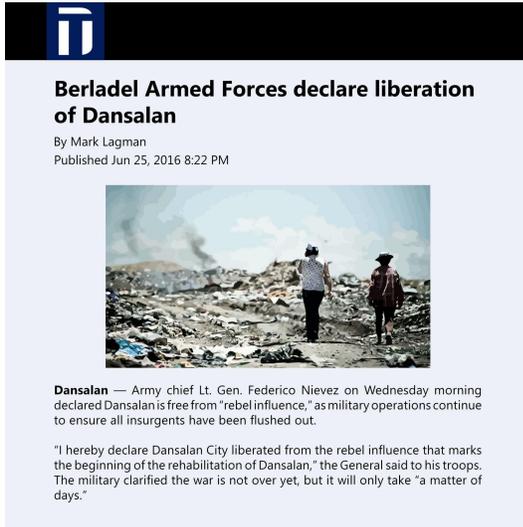


Figure 10: Example of a True Article

Another type of article is the Fake Articles. The Fake Articles are deemed fake in the fiction of the game, and the reasons they are fake are varied. Out of the eight methods taught by the game, six of them have articles created with those methods in mind. For example, for the method 'Check the date,' the article will have been published in a year different from that of the current stage. The other two methods that could not be cleanly converted into articles are 'Consult an Expert' and 'Personal Biases'. The former will be introduced as a hint system in the game, and the latter will be introduced narratively in the later stages as the player learns that their character could have a personal stake in the game.

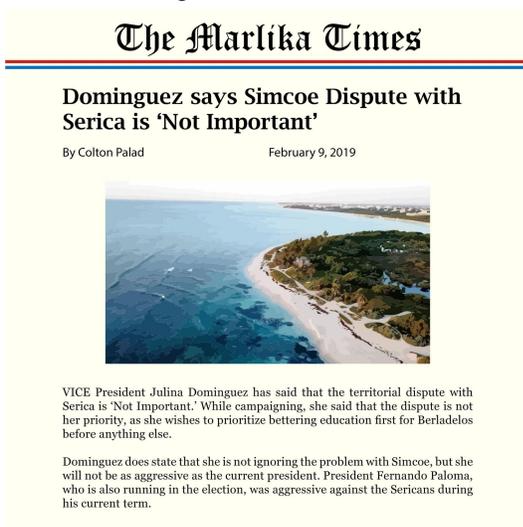
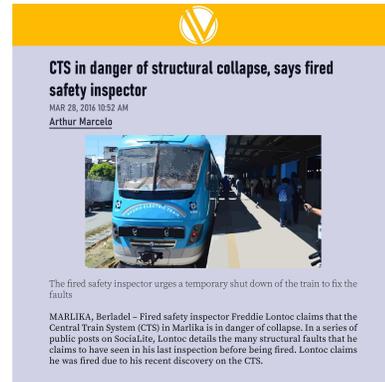


Figure 11: Example of a Fake Article for the method Reading Beyond the Headline

Two more types of articles will be Story Articles and Consequence Articles. Story articles are news stories that will help progress the story of the game further along. They will not be part of the randomized pool of articles, but will always be guaranteed to show at their respective levels. Depending on how the Story Articles are flagged, whether as true or fake, they will have a Consequence Article based on the player's choice that will show up in a future level.



**SOCIALite News**

**CTS to temporarily shut down pending safety inspections**

Katelynn Degayo  
 Posted on Oct 18, 2016 3:21 p.m.



MARLIKA, Berladel - The Central Train System (CTS) in Marluka is temporarily shut down due to multiple safety complaints from the public. The Department of Transportation (DOT) demands that the CTS management look into these complaints. The DOT will be sending their safety inspector to check on the structural integrity of the train.

CTS will be in a temporary shutdown starting tomorrow, October 19. When the CTS will be operational is still unknown, although it is estimated to be back up in four months.

**SOCIALite News**

**13 injured, no deaths in CTS derailling accident**

Katelynn Degayo  
 Posted on Oct 18, 2016 3:21 p.m.



MARLIKA, Berladel - Berladel Police (BerPol) were called on Tuesday morning, February 13, to a scene of a crashed Central Train System (CTS) rail vehicle that derailed at approximately 7:20 AM.

Currently, at least 13 people are injured due to the accident. No deaths have been recorded. The Department of Transportation will be sending a safety inspector to investigate the incident. CTS will be on temporary suspension until further notice.

Figure 12: Example of a Story Article (top) and its Consequence Articles (middle, bottom)

Lastly, the final type of article will be the Supporting Article and only shows up in the eighth stage. The final method that the game teaches is 'Check Supporting Sources', which means to see the article that the main article's author is using to support their own story. These articles only show up in this stage, and they are all being referred to by an article that will also show up only in the final stage.



Figure 13: Example of an article (top) and its Supporting Article (bottom)

#### 4.1.2.4 Emails

Emails will be a mechanic players will encounter at the start of each level. Emails will be a supplement to the tutorial within the game, as well as a narrative tool that will try to push the story along. These will be sent to the player by two entities, Illuminant and Socialite. The Illuminant emails will focus on teaching the players what new method the upcoming level will present. On the other hand, the Socialite emails will be more about the social media company's reputation, both internally and with the player. In the game world, Socialite's reputation has been damaged due to the abundance of fake news on its site, hence the partnership with the fact-checking organization Illuminant. As the game goes on and depending on how the player will do in spotting

the fake articles, Socialite will be reacting to the player through the email system.

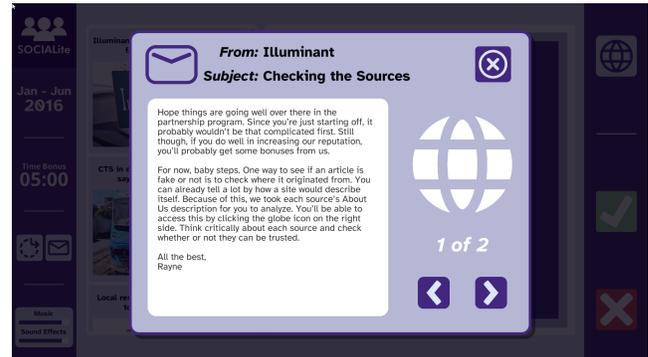


Figure 14: Example of an email teaching the method Check the Source

#### 4.1.2.5 Hub World

The hub world will be the place where the player would return after each level. This is a new section for this iteration of the game, both to address the feedback from the previous iteration and to add new features in the game that would deepen the experience a bit more. Since the stages of the game will simulate what a social media feed would look like, the hub world in the game will be a fact-checking suite. This is to keep the illusion of the simulation, wherein after the player completes a stage, they would switch from the social media app to their Illuminant workspace to prepare for their next task. Whenever a player finishes a stage, they will be taken directly into the hub world, where they will then have access to the workspace features. Not all features will be available from the start, as some features will be gradually introduced

The workspace will have a couple of features available to the player, but as the game goes on, a few more features will be introduced. These features are meant to help the player in their game experience and supplement their learnings about fake news.

One feature would be the store, which lets the player spend the points they've gained from playing on perks and cosmetics. These cosmetics will have no effect on the gameplay and it only meant to flourish in the hub world. Cosmetics players can purchase include new themes which are meant to change the color scheme of their suite, an Illuminant message board that showcases random messages from different co-workers, and other workspace widgets that will fill up the empty space in the hub world, such as a clock, calendar, and weather widget.

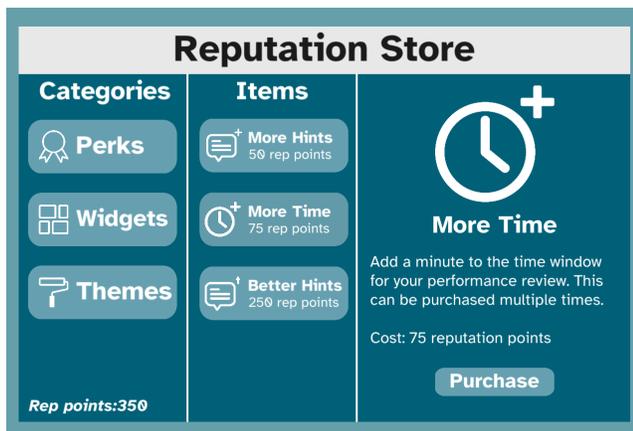


Figure 15: The Reputation Store

The feedback feature allows the player to review their previous level. As stated previously, one complaint received in testing before was the lack of explanations as to why players flagged an article wrongly. The feedback feature should then address this by giving players reasoning behind some flagging choices. When accessing this feature, the screen will show them a list of all the articles they were given in the previous level, what they flagged it as, and what the correct flag is. If the players choose to inspect further, they will be able to once again check the source, the author, or the support that is linked to the article. Along with that, they will also be able to check the feedback on the article, which is the explanation as to why the article is either fake or not.

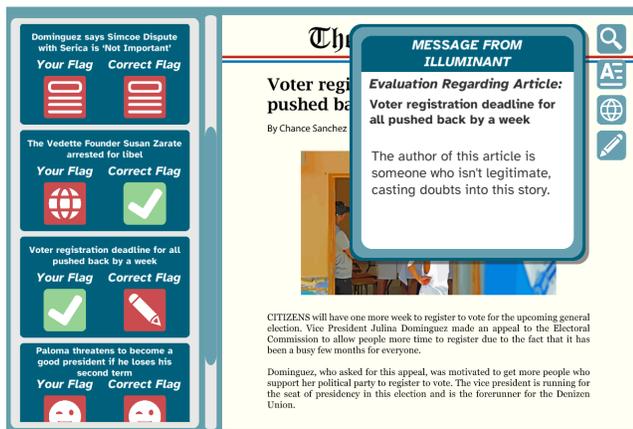


Figure 16: Feedback

The codex feature will allow the player to learn more information about fake news that is not inherently taught to the player in-game. Since the game only directly teaches the player methods on how to spot fake news, the codex will be meant to supplement this information with more knowledge on fake news and its nature. The codex feature will be unlocked after stage 3, which is the stage

that introduces Consulting the Experts. This is so that it coincides with the previous stage, with the codex being information coming from experts. The codex will go into topics like definitions of fake news, types of fake news, elements of fake news, parameters in fact-checking, and biases in fact-checking. It will also have a section on the methods of spotting fake news (which is what already the game teaches) for convenient access. These sections will also be unlocked gradually as the game progresses, meaning some sections will not be available at the start. This is so that the players will not be overwhelmed with information, and that they will also have time to process the information should they decide to read everything available to them. All information in the codex will be based on the United Nations Educational, Scientific, and Cultural Organization (UNESCO) published book titled Journalism, 'Fake News' & Disinformation [2].

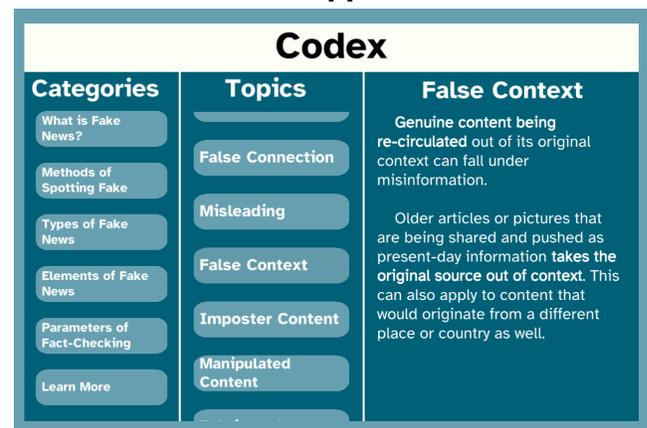


Figure 17: The Codex

#### 4.1.2.6 Reputation

Reputation will be the equivalent of a scoring system within the game. In the narrative of the game, Illuminant, the organization the player is working for, is relatively new. With the Socialite partnership being their first big job, the player's action would directly impact Illuminant's reputation. Each correct or partially correct flagging will increase the credibility of the fact-checking organization the player is working for. At the end of each level, players will gain reputation points equal to the score they received.

Depending on the player's total reputation points gained, organizations in the story such as Socialite will also react differently to the player, mostly seen through the email system. If the total number of reputation points the player has is below a certain threshold, the narrative of the game will count it as Illuminant having a bad reputation. Because of this, Socialite will be more passive-aggressive in tone in their emails to the player. Conversely, if the player's total reputation is above the threshold, Illuminant will have a

good reputation, with Socialite being more supportive in their emails as well. Along with the relationship of Socialite towards the player, reputation will also affect another part of the narrative. Since the story of the game will end in a general election, the winner of the election will be dependent on whether the player's total reputation is above or below the threshold.

Players in between levels may also use their garnered points at a reputation store, in which they can spend their points to unlock perks and cosmetics within the game. Buying perks will aid the player in certain aspects of the game. Along with perks, players will also be able to purchase cosmetics for their hub world. As stated in the hub world section, these cosmetics have no gameplay value, unlike the perks. These cosmetics are only meant for the player to personalize their own hub world, and each cosmetic will cost around 25 reputation points.

## 4.2 Test Results

In the end, there were 26 responses in the feedback form.

### 4.2.1 Quantitative Feedback Data

For their feedback on the game in general, participants were asked various questions regarding the gameplay and graphics of the game, and they were asked to rate their agreement with the questions on a scale of 1 to 6, with 1 being strongly disagree and 6 being strongly agree. Listed below are the questions that were asked and the average score among the 26 responses of the participants.

Table 1: Average scores of the questions asked in the feedback form

Question	Average
Were you able to learn more about fake news and how to spot them through the game?	5.48
How confident are you now in spotting fake news?	4.60
Is the game easy to play?	4.88
Did the game have clear goals?	5.48
Is the game enjoyable to play?	4.56
Are the mechanics of the game easy to learn and pick up?	4.92
Do you feel that the game responds to your actions properly?	5.36
Is the UI of the game intuitive?	4.48
Is the game easy to navigate?	4.88
Are the menus and buttons clear and readable?	5.12

Are the articles in the game clear and readable?	4.52
Are the design of the articles and news sources memorable?	4.72

Along with the average score between all responses, it was also noted how many times the score of 3 and below were answered for any question. 3 questions had a significant number of scores of 3 and below, those being "Are the design of the articles and news sources memorable?" having 5 of such responses, "Is the game enjoyable to play?" having 6, and "Are the articles in the game clear and readable?" having 8.

### 4.2.2 Qualitative Feedback Data

In the feedback form, participants were asked to list down the methods of spotting fake news they were able to learn through the game. Listed below are the methods that the game was meant to teach and how many times the respondents stated it in their answers. It should be noted that this may not take into account methods the participants already knew before playing the game. Some of the participants have stated in their form that they already knew some methods that were taught by the game, without listing which ones they already knew beforehand. It would be unknown whether the methods listed by the participants are inclusive of methods they are familiar with already, or if they have omitted some methods taught by the game that they already knew.

Table 2: Methods in the game and times they were stated in the form

Method	Times Stated
Consider the Source	13
Check the Author	13
Consult the Expert	0
Read beyond the Headline	9
Is it Satire?	6
Check the Date	7
Check Personal Biases	1
Check Supporting Articles	9

On average, 'Check the Source' and 'Check the Author' are the most remembered by the players, which can be explained by how they were the first 2 methods introduced by the game.

The methods with the least mentions in the feedback form are 'Check Personal Biases' with only 1 mention, and 'Consult the Experts' with 0 mentions. This

can be attributed to the fact that these were the only methods that were not fully gamified. The former just became a hint system to simulate the player consulting another person in their company. The latter has no equivalent feature in the game due to the subjective nature of bias and how it differs from person to person. Essentially, some articles after the introduction of the method would be more politically charged, in hopes that before that players would already be invested in the world of Berladel and form their own opinions of the politicians, and be able to check their biases on articles that are more based in the politics of the world.

Lastly, participants were also asked what they liked least and most in the game, as well as general feedback and comments the previous questions were unable to provide a space to answer. When the previous answers in regards to the features of the game asked for their agreement to the question on a scale of 1 to 6, these questions asked for their short responses, meaning the content and length of each response differed per respondent. There were, however, recurring answers to what players liked the most and least in the game. In terms of what players liked the most about the game, they liked: the UI and UX of the game (with 4 respondents having answered this), the codex feature (with 5 respondents), that the game introduced new mechanics and increased the challenge per level (10 respondents), and the world-building of the game, which includes the content of the articles and the story of the game (11 respondents). In terms of what players liked the least about the game, they did not like: the tediousness of reading the articles (3 respondents), the UI and layout of articles, more specifically both being too cramped (4 respondents), and that the tutorial stage and subsequent tutorial emails were difficult to grasp (8 respondents).

## 5 Conclusion

### 5.1 How does one design a game that teaches players multiple methods of spotting fake news?

In terms of what type of game to create to teach the methods of spotting fake news, a puzzle simulation game would be best. A puzzle game engages the player in logical challenges that will make them use the methods the game wants to teach to be able to solve said puzzles. Along with this, the simulation aspect of the game would give it a more familiar environment, being that the game tries to emulate how the news would look on social media online. This would also help the players use the methods they learned through puzzle-solving in applying the skills outside the game.

#### 5.1.1 What elements of gameplay can be employed in a puzzle simulation game to make players remember how to spot fake news?

The main gameplay loop of Missed Information is for players to inspect articles, read them thoroughly, and determine whether the said article is fake or not. If the article is fake, the player must then decide what method was most applicable in their reasoning as to why they deem it fake. This will make the player critically think about what method they used, and since they will be effectively doing this multiple times throughout the whole game, it will hopefully instill the knowledge of how to spot fake news into the players. In terms of showcasing the goal of the game, testers strongly agree with the goal of the game being clear, with an average score of 5.48 in the feedback form.

A scoring system was also in place to incentivize the players to do well in the game. Players are rewarded with an uptick in their score should they accurately point out the truthfulness, or lack thereof, of an article. The game also implements a time limit system, however, the time limit is only for bonus points. Due to the educational nature of the game, it should not limit players who take their time in playing the game. Therefore, players who are looking for an extra challenge may be able to finish the stage under the time limit and are then rewarded with extra points, while players who are unable to do so are not punished with a game over, rather they can still play and finish the current stage they are in.

The game will also be introducing each method per level, so as to not overwhelm the player immediately with 8 different methods at once. This will also steadily increase the challenge of the game as the players go through the level. In terms of the steady increase of challenge, the testers have responded positively to it, with 10 responses claiming such. Along with that, respondents generally agree that the mechanics were easy to learn, with an average score of 4.92, and they strongly agree that the game was responsive towards their actions, with an average score of 5.36. However, on average, respondents had a certain degree of difficulty nonetheless even with the paced introduction of each method, scoring an average of 4.88 when asked if the game was easy to play in the feedback form. This can be attributed to certain gameplay features that players liked the least.

The large amount of reading required by the game is a feature some testers deemed unfavorable. Due to it being the main gameplay loop, the only thing players will be doing for most of the game is reading news articles after news articles. For some players who are already not used to large amounts of reading, they would understandably find it boring. Although a relatively true simulation of how a news-only social media feed would look like, the huge

amount of text to analyze may be too much for some players. This may be what led to the average score of 4.56 when players were asked about the game's enjoyability.

The narrative of the game would also be able to gauge the interest of the players and lead to players being more invested in the world the game would be presenting. The narrative also serves the purpose of immersing in the different world the game is presenting, that being the country of Berladel and their job as a social media fact-checker for Socialite. This would also justify why the game would look like a social media feed, but only just news headlines. Along with the fictional country, the game would also fabricate its own news stories, news sources, popular figures, and recurring side stories within the game. For instance, one of the main focuses of the latter half stages of the game would be the Berladel election, wherein certain news stories would then focus on the topic. This will give the game world the feel of being dynamic, not only reacting to the player's actions but also acting on without their input. Testers actually mentioned that they enjoyed the presentation and atmosphere the game presented, a sentiment echoed by 11 different respondents. The investment and immersion of players within the game would help them learn the methods better, and will also aid them in applying such skills in real life.

#### **5.1.2 What elements of gameplay can be employed in a puzzle simulation game to make players remember how to spot fake news?**

As stated in the Results section, six of the eight methods were essentially gamified in the game, wherein the player will be able to inspect certain aspects of the article that pertain to the method. These methods will be introduced per level as a new feature, and they will also be able to pick that option if they choose to red flag an article.

The method 'Check the Source' allows the player to see which site an article originated from. 'Check the Author' lets them see who wrote the article. 'Read Beyond the Headline' informs the player that they should read the whole article to see discrepancies within the title and the body. 'Is it Satire?' adds satirical posts to the pool of articles in the game. It is also good to note that due to satire articles being the easier type of fake news to be spotted by the players, and that some players found said articles as entertaining, the level that introduces satire and all satire articles moving forward has a double purpose of being a breathing room in the steady increase of challenge of the game. 'Check the Date' informs the players to be aware of when the articles were posted. 'Check the Supporting Article' adds a feature to see another article that is being referenced by the primary article. On average, 'Check the Source' and 'Check the Author' are the most remembered

by the players, which can be explained by how they were the first 2 methods introduced by the game.

The only methods that were not gamified fully are 'Consult the Experts' and 'Check your Personal Biases.' The former just became a hint system to simulate the player consulting another person in their company. The latter has no equivalent feature in-game due to the subjective nature of bias and how it differs from person to person. Essentially, some articles after the introduction of the method would be more politically charged, in hopes that before that players would already be invested in the world of Berladel and form their own opinions of the politicians, and be able to check their biases on articles that are more based on the politics of the world. Due to these 2 methods not being fully gamified, these are also the 2 methods least remembered by the testers after playing the game, with 1 respondent stating 'Check Personal Bias' when asked what they learned from the game, and 0 respondents for 'Consult the Experts.'

### **5.2 How effective will the game be in teaching players methods for spotting fake news?**

Due to how prevalent the topic of fake news has been since 2016, to a certain extent, most people already have their ways of checking if a news article is fake or not. This was shown by how some respondents said in their feedback form that they already knew some of the methods the game was trying to teach. However, the game can still be used as a way to deepen the player's knowledge of fake news and methods of teaching, and also be used as a platform to be able to apply these methods and get feedback from the game.

In terms of the effectiveness of the game in teaching the methods it was meant to teach, it can be said that the game was fairly effective. When asked if the players were able to learn more about methods of spotting fake news, they gave it an average score of 5.48. When asked to list the methods they remember the game teaching them, most of the methods taught by the game were at least mentioned a significant amount of times.

As previously stated, the methods most repeated by the respondents are 'Check the Source' and 'Check the Author,' due to the fact that these are the first 2 methods taught by the game. The only 2 methods barely mentioned by any respondents are 'Consult an Expert' and 'Check your Personal Bias.' The lack of gamification from the methods made it so that they technically weren't able to properly apply these 2 methods compared to the other methods. Due to the lack of application, the respondents may have tended to not remember it more. It is also good to note that some of the methods the game is meant to teach are already

methods some respondents employ. This can be another reason why they did not list it anymore when asked what methods of spotting fake news they learned from the game. Overall, other than the 2 non-gamified methods, the game was able to teach the other 6 methods to the player.

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# Locked Down

## A Video Game About the Struggle of the Poor in the Philippines During a Pandemic

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### ABSTRACT

The objective of this study is to create a new game mode that can increase a person's empathy towards the police, as well as reduce their tendency to stereotype them. The study aims to replicate various real life events in the game to allow players to experience them through the lens of the less fortunate. The proponents will try to achieve this goal by letting participants play a 3D stealth game wherein the participant must help the main character, Michael Crisostomo, return home safely. The participants' levels of empathy did change depending on the ending they chose; however, the relationship between the game and their levels of empathy was found to be insignificant, which means that there may be other factors that caused these changes.

### CCS CONCEPTS

• Applied computing → Education → Interactive learning environments

### KEYWORDS

Poverty, Serious Games, Perspective-taking, Social Empathy

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## 1 Introduction

### 1.1 Context of the Study

Even in the 21st century, poverty continues to be a major worldwide problem. Poverty, as defined by the United Nations Development Programme (UNDP), not only means having a low income, but also “reflects poor health and education, deprivation in knowledge and communication, inability to exercise human and political rights, and the absence of dignity, confidence, and self-respect” [18]. In their 1998 Human Development Report, the UNDP added

that “poverty can also mean the denial of opportunities and choices most basic to human development” [19].

Though the poverty rate in the Philippines in 2018 was lower compared to the previous year, the UNDP believes that the current pandemic may cause millions more to fall into multidimensional poverty [11, 20].

The importance of empathy, with regards to addressing poverty, lies in the fact that having social empathy will allow “public responses to social problems to be designed to address real circumstances” [17]. Social empathy, a concept introduced by Segal, refers to “the insights one has about other people’s lives that allow one to understand the circumstances and realities of other people’s living situations” [17]. In addition to social empathy, the concept of perspective-taking is also important because it allows people to see things from another’s view, which helps them empathize with the other [16].

In a previous study, a 3D stealth game was created as a way to address the poverty issue in the country. The results showed that the game was found to be successful in raising the player’s empathy towards the poor. However, while the game did feature a morally-conflicted policeman, players were unable to learn more about his struggles. This made the game rather unbalanced because the policemen were mostly shown in a bad light.

### 1.2 Research Objectives

The researchers aim to create a new game mode which simulates the internal struggles faced by the policemen during a pandemic. Through the game’s narrative and mechanics, the researchers aim to lower the players’ tendency to stereotype the police through perspective-taking.

### 1.3 Research Questions

This study aims to answer the following questions: (1) What mechanics should the game have to increase one’s empathy towards the police? (2) What game elements can be used to represent the internal struggles faced by the police during a pandemic in the Philippines in a video game? (3) How effective is the game in increasing one’s

empathy towards the police and reducing their tendency to stereotype?

#### 1.4 Scope and Limitations

This research will only be targeting adult Filipinos whose ages range from 18 to 30 years old and are from a middle to high socioeconomic class. It will be focused on the Philippine context and will not be concerned with poverty in other countries, or in general. Furthermore, this research will specifically focus on the struggles faced by homeless scavenger children only. As such, it will not be dealing with other representatives of the underprivileged community.

The game will only be available on PC (specifically those running Windows 7 or above) and will be created using the Unity game engine (version 2021.2.7f1).

#### 1.5 Significance of the Study

This study aims to help address the tendency to stereotype the police in the Philippines. Due to recent events, the police are often viewed in a bad light. While there are certainly members of the police force who are selfish and cruel, it is important to remember that there are also good policemen who struggle with following harsh and questionable orders. The use of a game in this study will help achieve this goal by allowing the user to simulate the internal struggles faced by these policemen.

There has been evidence that video games, even those developed solely for entertainment, can trigger serious emotions and improve learning [13]. Their interactive nature provides people the opportunity to take the perspective of a character and identify with them [6, 14]. Studies have proven that people have the ability to form attachments to video game characters, which are able to influence their real-world interactions [4, 13, 15]. Thus, it can be said that video games can be used for effectively developing, or changing, a player's insight and their social skills in the real world [1, 13, 15].

## 2 Review of Related Literature

### 2.1 Social Empathy

The concept of social empathy was introduced by Segal in 2007 to address the growing disparity between those at the top of the socioeconomic ladder and those at the bottom [17].

Social empathy is defined as "the insights one has about other people's lives that allow one to understand the circumstances and realities of other people's living situations" [17]. This understanding makes it possible to create solutions which can effectively address the needs of the impoverished.

Segal proposes a three-tier model with Exposure, Explanation, and Experience as the levels to being socially

empathic [17]. The third level, Experience, is described as the participation or immersion in the daily lives of those in need, thus providing the deepest understanding of their situation and contributing most to developing social empathy [17].

Prior to reaching this is the second level, the Explanation stage. Here, one ponders about the lived experiences of other people once they've already been made aware of them through the first level, Exposure [17]. This level requires a deep reflection and aims to explain why people are different, what makes them different, and what these differences could mean [17].

### 2.2 Perspective-taking

Perspective-taking is defined by Gehlbach as the strategies used to understand others' thoughts, feelings, and perceptions of certain situations [7]. In addition to this, Johnson describes the necessity of a social awareness that comes with perspective-taking: that a person needs to recognize that other people have points of views that are different to one's own [7, 8]. Thus, perspective-taking goes beyond simply sympathizing with others; it is the ability to understand how others may be affected by situations that are different from one's own and to see things in the context of other people [7, 8, 16].

Besides practical benefits such as proper needs assessment, studies have shown social benefits of perspective-taking such as increasing social understanding, reducing the propagation of stereotypes and aggression driven by stereotypes against certain groups, fostering cooperation, promoting moral reasoning, and encouraging altruistic behavior and conflict resolution [16, 17].

In terms of Segal's three-tier model for social empathy, perspective-taking occurs within the second level, the Explanation stage, as it allows oneself to understand others' thoughts, feelings, and motives [7, 8, 16]. Understanding the point of view of others through perspective-taking, coupled with the knowledge that stems from actually experiencing the lives of others, makes way for one to be socially empathic based on Segal's model.

Researchers have classified perspective-taking into two forms, namely the imagine-other perspective and the imagine-self perspective [1]. The first form, the imagine-other perspective, is described by Batson as a phenomenon of empathy where one imagines what another is thinking and feeling while retaining information based on the self's life experiences [1, 3]. The second form, the imagine-self perspective, is described by Batson as a phenomenon of empathy similar to the previous, but instead, the self projects his mental state into the other [1, 3].

### 2.3 Perspective-taking and Video Games

The imagine-self perspective is more relevant to catalyzing a player's empathy via playing a video game [1]. Depending on the degree to which they immerse themselves in the game's narrative and gameplay and on how much they consider the context of the characters, the player also takes a perspective that is at the very least slightly different from their own [1]. In contrast, the player cannot adopt a fully imagine-other perspective since they must react to the events in the game, thus such psychological distance from the game cannot be maintained [1].

Perspective-taking in games is ideal for catalyzing prosocial behavior, since having a player "walk in another person's shoes," can present them new experiences they may not have the opportunity to experience in real life [1]. Games that depict the suffering of certain people may also help catalyze emotional empathy and care for the welfare of another [1]. For example, playing as a character of an oppressed group and navigating through scenarios that mimic real-life situations may help in gaining a better understanding of the microaggressions that the group experiences [1].

These in-game experiences will rarely be as intense as they are in real life, but they are able to provide the player insight about certain topics, as well as challenge the player's preexisting worldviews to "create a new model that is coherent with both personal values and the data the player has acquired through a simulated experience about how the world works" [1, 12, 15].

## 2.4 Serious Games as a Tool to Change People Attitudes

In a study conducted by Mota, Botelho, and Adamatti, six students were interviewed regarding their perceptions of games [10]. The purpose of their research was to analyze the influence of games in the students' lives and determine how games can change one's attitude [10]. Based on the data gathered from both the interviews and the references used by the researchers, it was concluded that games are effective tools to teach serious topics, promote social skills through interaction and participation, and improve cognitive skills such as the ability to process larger information, to reason and analyze, and to learn through experimentation [10].

In another study, 31 participants were chosen to either spectate or play the game RePlay Health [9]. The goal was to determine whether the game is effective in positively changing one's views on public health and healthcare policies [9]. The study concluded that games could have a lasting effect on one's perceptions and attitudes towards a certain topic through several factors such as the game's narrative and role-playing aspect [9].

Similar to the previous study, the research regarding RePlay Health proved that games have the ability to shape/influence one's attitude.

## 2.5 Effects of a Serious Game on Role-Taking and Willingness to Help

In 2010, a group of researchers conducted a study to determine the effectiveness of video games on "role-taking and helping behaviors" compared to other forms of media [14]. A hundred and thirty-three participants were randomly assigned to either play the game, read a text regarding the conflict in Darfur, or watch a presentation about it [14]. The results showed that using games was more effective in influencing people's empathic reactions to social issues as compared to the other forms of media, thus evoking a stronger sense of role-taking and willingness to help within the players [14].

## 2.6 Video Game Elements

In a paper written by Alexiou and Schippers, they cite Eseryel et al. and Lester et al. when saying that "narrative can be considered as one of the main pillars of educational game effectiveness due to the applied, and often complex nature of these games" [2]. According to them, players are able to take the place of their character and process events and happenings within the game from the character's point of view [2].

There is also a discussion on the game's aesthetics in the paper, wherein they state that a more realistic game makes it easier for a "transfer of knowledge" between the game world and the real world due to its similarities [2]. They also cite Wood et al. when saying that a game's success is greatly influenced by its degree of realism [2].

In another study, it was discussed whether players' preferences regarding point of view affect their immersion [5]. Participants were tasked to complete a quest in Skyrim while playing in either a third person point of view or a first person point of view, depending on which group they belonged in [5].

The researchers concluded that a player's preference does not affect immersion and that there may be increased immersion in a first person perspective compared to a third person perspective; however, there may be a "cost of a reduction in other aspects" such as social presence [5]. The researchers also stated that there may be other factors that affect immersion, depending on the game's genre [5].

## 3 Methodology

### 3.1 Initial Research

Prior to the game's development, the proponents of this study searched for numerous real-life events which can be used in the game's narrative. The results were used to determine which game mechanics, and elements, were necessary to allow for a more realistic simulation.

### 3.2 Game Mechanics

The mechanics of this study's game were based on the real-life experiences of the police officers during a pandemic. As the main character is a morally conflicted police guard, the player has to guide a homeless child through various levels in order to progress by interacting with dumpsters, gates and other police guards to make a path for the child.

Similar to the mechanics, some events in the game's narrative were also inspired by real-life events that have occurred as a result of the Philippines' quarantine period during the past two years.

### 3.2 Tools Used

For the game engine, the researchers used Unity. 3D models were downloaded from either the Unity Asset Store or other websites. Blender was also used to modify some of these pre-existing 3D models, while Adobe Fuse was used to create the guard models. Audio clips used in the game were downloaded from Freesound, and animations were taken from Mixamo. Visual Studio Code was used as the external text editor.

### 3.3 Game Elements

Since the goal of the researchers was to increase one's empathy towards the police by portraying their internal struggles, the new mode needs to be able to show the morally-conflicted policeman's thoughts, as well as the actions he chooses to make. The game elements used should also match the real-world situations that the policemen experience to make the game more realistic.

Due to the game's setting, there are guards that need to be avoided in order to progress.

In the new mode, players control the morally-conflicted guard to guide the homeless child "home". The player must avoid the other policemen while doing so, since they will report him (the morally-conflicted policeman) to the higher-ups for not following orders.

The player may interact with gates and dumpsters to make a path for the child or block the policemen's way. They may also interact with some policemen and bribe them to make them more lenient.

Cutscenes are placed to show the different situations faced by the characters during a state of pandemic. Having cutscenes will aid in the storytelling aspect of the game, which will allow the player to better understand the police.

### 3.4 Game Design

The game developed by the researchers is a stealth game based on the experiences of a homeless scavenger child, and a morally-conflicted policeman, during a community quarantine period.

Aside from the homeless scavenger child and the morally-conflicted policeman, the other significant characters in this game are the guards, who make sure that the quarantine's curfew rules are being followed. Though not inherently evil, they serve as "antagonists" to the player since the homeless child has nowhere to stay during the curfew period and, therefore, cannot abide by the rules.

In the main mode, the morally conflicted guard is also present as a patroller. However, he is more understanding of the protagonist's situation and, therefore, more lenient when it comes to catching protocol violators.

The player can only do simple movements such as running, crouching, and peeking, in order to hide from these policemen.

The policemen carry flashlights that will allow the player to know when they are approaching; these also serve as the policeman's view cone. The morally conflicted guard (in the main mode) also has a differently-colored flashlight to better tell the difference between the two.

In the main mode, the player's goals are to make it to the exit point without getting caught and to collect all the necessary quest items. In one stage, they must also be careful not to let their HP drop down to zero.

In the alternate mode, they must also avoid the policemen; however, in addition to this, they must also ensure that the homeless child does not get caught and makes it back home safely.

### 3.5 Game Development

The game is built using Unity, specifically version 2021.2.7f1, and the scripts used in the game were written in C# language.

For the game's resources, the researchers used free assets found online. The 3D models were obtained from the Unity Asset Store or from websites with free FBX files, and the animations used were taken from Mixamo. Adobe Fuse was used to create the characters' 3D models, and Blender was used in cases where the desired model cannot be found anywhere. The audio files were obtained from Freesound, a repository of Creative Commons licensed audio samples.

### 3.6 Testing

Two rounds of testing were held for this study. The game's alternate mode was tested by a total of twenty-two Filipino adults, who were at least 18 years old, and at most 30 years old. All participants come from a middle to high socioeconomic status and have some experience with games.

Participants were not asked to play the main mode in this study, since it has already been concluded in a previous study that the game's main mode had a significant relationship with the increase in the players' levels of social empathy.

Before they played the game, they were given a pretest containing a modified Social Empathy Index (SEI) and an Adjective Checklist (AC). These were used to determine the player's initial thoughts regarding the police force.

Below is a list of the survey items included in the modified SEI. A 6-point Likert scale was used to determine how strongly the participants agreed or disagreed with each item.

**Table 1: Modified SEI Items**

1.	I believe that people who faced discrimination have added stress that negatively impacts their lives.
2.	I believe the role of government is to act as a referee, making decisions that promote the quality of life and well-being of the people.
3.	I believe that by working together, people can change society to be more just and fair for everyone.
4.	I can best understand people who are different from me by learning from them directly.
5.	I feel it is important to understand the political perspectives of people I don't agree with.
6.	I believe my actions will affect future generations.
7.	I take action to help others even if it does not personally benefit me.

The list of adjectives present in the AC may also be viewed below.

**Table 2: Modified AC Items**

Aggressive	Grasping	Methodical	Sportsmanlike
Ambitious	Honest	Nationalistic	Straightforward
Arrogant	Impulsive	Passionate	Suspicious
Courteous	Industrious	Patriotic	Treacherous
Cruel	Kind	Proper	Unreliable
Deceitful	Materialistic	Quick-tempered	Witty
Effective	Meditative	Shrewd	
Generous	Mercenary	Sly	

After playing the game, the players were given a posttest to check for any increase or decrease in their levels of social empathy. The posttest also allowed the researchers to determine whether there is any change in the players' views of the police or not, through the AC.

A survey on the Heuristic Evaluation of Playability (HEP) was also given along with the posttest. This allowed the players to rate the game in terms of its gameplay, story, usability, and mechanics.

Below is a list of items included in the HEP survey. Similar to the modified SEI, participants rated the game using a 6-point Likert scale.

**Table 3: Modified HEP Items**

Gameplay	
1.	There are a variety of activities in the game.
2.	The player is provided clear goals throughout play.
3.	The player is given instructions for every mechanic in the game.
4.	The game is fun for the player.
5.	The game is paced well.
6.	The player enjoys the challenge of the game as it progresses.
Game Story	
7.	The storyline is cohesive.
8.	The storyline is interesting.
9.	The story relates to real life.
10.	The game triggered an emotional response(s) from the player.
11.	The aesthetics of the game (visuals and audio) aided in triggering an emotional response(s).
Game Mechanics	
12.	The player is able to see their progress, score, or status throughout the game.
13.	The game controls are easy to learn.
14.	The game controls feel natural.
Usability	
15.	There is immediate feedback from the game when the player does actions.
16.	There is no instance of the player getting stuck in a level.
17.	The interface (health bar, timer, in-game texts etc) is not intrusive to gameplay.

For this study, the researchers aim to reach a score of at least 85% in all four aspects of the game.

## 4 Results

### 4.1 Development Results

After following the above methodology, the researchers created a new mode that follows the daily life of a morally-conflicted policeman during quarantine.

Due to the lack of 2D assets, the dialogues for the game's cutscenes were mostly replaced with a narrative version.

Other aspects of the game, such as its mechanics, were successfully developed and confirmed to be working properly prior to testing. Other in-game functions, such as saving and loading, were also tested and confirmed to be fully functional.



Figure 1: Policeman with a Yellow Viewcone



Figure 2: Interactable Objects with Green Light

The researchers were also able to obtain all the necessary assets, such as the game's audio and 3D models, and place them in the game's stages. Similar to the other assets, the game's HUD was also made using free fonts and sprites obtained from websites.



Figure 3: Alternate Mode HUD

### 4.2 Survey Results

Two rounds of testing were conducted for this study. The results of the first round in the pretest and posttest were analyzed as a whole, while the second batch of results were grouped into two, depending on the players' chosen ending.

#### 4.2.1 First Round of Results

After conducting the pretest and posttest, the percentage scores of each participant's SEI results were computed. These results can be viewed in the table below.

Table 4: First Round of SEI Scores

Participant	Pretest Score (%)	Posttest Score (%)
1	83.33	94.44
2	79.17	61.11
3	100.00	100.00
4	83.33	94.44
5	87.50	100.00
6	95.83	94.44
7	83.33	61.11
8	91.67	83.33
9	91.67	94.44
10	75.00	94.44

A paired samples t-test was conducted to compare the means of the participants' SEI scores before playing the researchers' video game and after. The total SEI scores during the pretest were lower (M = 87.08, SD = 7.32) than during the post-test (M = 87.78, SD = 14.01). The table below shows that the difference between the scores is not significant at  $\alpha < 0.05$  ( $p = 0.87$ ).

Table 5: First Round of Paired Sample T-Test Results

	N	Mean (M)	Standard Deviation (SD)	t	df	Sig. (2-tailed)
Pretest	10	87.08	7.32			
Posttest	10	87.78	14.01			
Pretest - Posttest		-0.69	12.94	-0.17	9	.87

Though the average score of the posttest is higher than that of the pretest, it was found that there is no significant relationship between the researcher's video game and the participants' level of social empathy toward the police.

After analyzing the participants' SEI results, the researchers tallied the amount of times each word was chosen in the AC to check for any changes. Below is a table containing the summarized results.

Table 6: Summarized AC Results for the First Round

Positive (Pre-Post)	Negative (Pre-Post)	Neutral (Pre-Post)
Ambitious (3-4)	Aggressive (8-6)	Effective (1-3)
Courteous (1-0)	Arrogant (6-6)	Impulsive (3-3)
Generous (1-2)	Cruel (1-1)	Mercenary (2-1)
Honest (0-0)	Deceitful (2-2)	Methodical (3-3)
Industrious (0-1)	Grasping (0-0)	Nationalistic (2-3)
Kind (1-1)	Materialistic (3-5)	Straightforward (1-2)
Passionate (3-4)	Quick-tempered (3-4)	
Sportsmanlike (0-1)	Shrewd (0-0)	
Witty (0-1)	Sly (0-0)	
	Suspicious (5-4)	
	Treacherous (0-1)	
	Unreliable (8-7)	
<b>Overall: 9-13</b>	<b>Overall: 36-36</b>	<b>Overall: 12-15</b>

As shown in the table, the adjective that was most picked during the pretest was tied between "unreliable" and "aggressive". After the game's testing, the most selected adjective then became "unreliable", followed by "aggressive".

As shown in the total tallies, there was no decrease in the amount of negative adjectives chosen in the posttest.

However, there was a slight increase in the amount of positive and neutral adjectives chosen.

Table 7: Individual AC Results for the First Round

Participant	Positive (Pre:Post)	Negative (Pre:Post)	Neutral (Pre:Post)	Total Tally (Positive, Negative, Neutral)
1	(0:1)	(6:2)	(0:3)	(+1, -4, +3)
2	(1:3)	(6:8)	(4:5)	(+2, +2, +1)
3	(1:1)	(2:3)	(0:0)	(0, +1, 0)
4	(1:0)	(2:5)	(3:0)	(-1, +3, -3)
5	(2:1)	(4:3)	(0:2)	(-1, -1, +2)
6	(0:1)	(5:4)	(1:1)	(+1, -1, 0)
7	(2:0)	(2:4)	(2:1)	(-2, +2, -1)
8	(1:1)	(4:4)	(0:0)	(0, 0, 0)
9	(0:1)	(2:0)	(2:3)	(+1, -2, +1)
10	(1:0)	(2:4)	(1:1)	(-1, +2, 0)

As shown in the individual results, most participants did have a change in the amount of positive, negative, and neutral words chosen. Though not all changes were positive, the results show that the game was capable of affecting the players' view towards the police.

Similar to the SEI survey, the participants' scores in the HEP survey were converted to percentages. The tables below show the data obtained from the test.

Table 8: First Round of HEP Scores

	Gameplay (%)	Game Story (%)	Mechanics (%)	Usability (%)	Overall (%)
1	88.89	83.33	66.67	77.78	81.37
2	66.67	66.67	55.56	66.67	64.71
3	100.00	100.00	94.44	88.89	97.06
4	86.11	86.67	83.33	88.89	86.27
5	97.22	93.33	83.33	88.89	92.17
6	83.33	90.00	77.78	83.33	84.31
7	66.67	73.33	61.11	94.44	72.53
8	58.33	70.00	88.89	55.56	66.67

9	63.89	86.67	50.00	50.00	65.69
10	86.11	93.33	88.89	66.67	85.29

Table 9: First Round of Summarized HEP Scores

Test	Mean (%)	Std. Deviation (%)
Gameplay	79.72	13.95
Game Story	84.33	10.44
Mechanics	75.00	14.75
Usability	76.11	14.71
Overall HEP	79.61	10.94

The results above show that there was still much to improve on, especially regarding the game’s mechanics. The survey items which scored low concerned the lack of clear instructions and goals in the game, the game’s aesthetics, the inability to see the player’s progress, and the high chances of being stuck in a stage. There was also an issue regarding the game’s controls being unnatural, but a keybinding system has already been implemented to allow players to modify the controls based on their preferences.

4.2.2 Second Round of Results

After the first round of testing, the researchers made a few changes in the game’s mechanics based on the previous HEP data.

One of these changes was to remove the peeking mechanic and the timer from the alternate mode. This was due to numerous comments from the playtesters that these mechanics were unnecessary.

Another change had to do with the bribable policemen. Previously, these policemen could only be interacted with if the player was behind them. Several players complained that this made them difficult to interact with, due to the other obstacles present in the game, as well as the small trigger areas. An additional text was also added so that players could easily know which policemen could be bribed.

Similar to the previous testing phase, the percentage scores of each participant’s SEI results were computed, but this time, they were grouped together based on the players’ chosen endings. These results can be viewed in the table below.

Table 10: Second Round of SEI Results (Good Ending)

Participant	Pretest Score (%)	Posttest Score (%)
-------------	-------------------	--------------------

1	91.67	88.89
2	100.00	100.00
3	79.17	94.44
4	70.83	89.89
5	95.83	88.89
6	70.83	72.22
7	91.67	100.00
8	91.67	83.33
9	79.17	77.78
10	91.67	100.00

Table 11: Second Round of SEI Results (Bad Ending)

Participant	Pretest Score (%)	Posttest Score (%)
11	75.00	66.67
12	75.00	77.78

A paired samples t-test for each group was conducted to compare the means of the participants’ SEI scores before playing the researchers’ video game and after.

For the group that chose the good ending, the average SEI score during the posttest (M = 89.44, SD = 9.11) was found to be higher than during the pretest (M = 83.75, SD = 9.21). However, the table below shows that the difference between the scores is not significant at  $\alpha < 0.05$  ( $p = 0.12$ ).

Table 12: Paired Sample T-Test (Good Ending)

	N	Mean (M)	Standard Deviation (SD)	t	df	Sig. (2-tailed)
Pretest	10	83.75	9.21			
Posttest	10	89.44	9.11			
Pretest - Posttest		-5.69	10.62	-1.70	9	.12

For the group that chose the bad ending, the average posttest score (M = 72.22, SD = 5.56) was found to be slightly lower than the pretest (M = 75, SD = 0). While the SEI results of those who chose the bad ending did decrease, it was found that the results for this group were also not significant at  $\alpha < 0.05$  ( $p = 0.61$ ). The table below

shows the values obtained from the SEI results of the second group.

Table 13: Paired Sample T-Test (Bad Ending)

	N	Mean (M)	Standard Deviation (SD)	t	df	Sig. (2-tailed)
Pretest	2	75.00	0			
Posttest	2	72.22	5.56			
Pretest - Posttest		2.78	5.56	0.71	1	.61

Similar to the first test, the participants were asked to choose any amount of adjectives to describe their thoughts towards the police before and after playing the game.

Table 14: Second Round of Summarized AC Results

Positive (Pre-Post)	Negative (Pre-Post)	Neutral (Pre-Post)
Ambitious (3-4)	Aggressive (8-5)	Effective (1-3)
Courteous (1-2)	Arrogant (7-5)	Impulsive (4-3)
Generous (0-2)	Cruel (4-3)	Mercenary (4-5)
Honest (0-2)	Deceitful (2-2)	Methodical (1-2)
Industrious (0-0)	Grasping (5-4)	Nationalistic (4-6)
Kind (1-2)	Materialistic (2-2)	Straightforward (1-5)
Passionate (2-2)	Quick-tempered (5-5)	
Sportsmanlike (0-0)	Shrewd (1-0)	
Witty (1-1)	Sly (4-3)	
	Suspicious (9-6)	
	Treacherous (1-1)	
	Unreliable (8-5)	
Overall: 8-15	Overall: 56-41	Overall: 15-24

For this round of testing, similar to the previous results, the most picked adjective during the pretest was "suspicious", followed by a tie between "unreliable" and "aggressive". After playing the game, the most picked adjective then became a tie between "suspicious" and "nationalistic".

As shown in the previous table, there was a decrease in the total amount of negative adjectives chosen by the

participants. Apart from that, there was also an increase in neutral and positive adjectives. These results show that the players' attitude towards the police has been changed to be less negative and more neutral and positive after playing the game.

Table 15: Individual AC Results for the Good Ending

Participant	Positive (Pre:Post)	Negative (Pre:Post)	Neutral (Pre:Post)	Total Tally (Positive, Negative, Neutral)
1	(0:0)	(6:2)	(0:3)	(+1, -4, +3)
2	(0:2)	(6:8)	(4:5)	(+2, +2, +1)
3	(0:0)	(4:3)	(0:2)	(-1, -1, +2)
4	(0:1)	(5:4)	(1:1)	(+1, -1, 0)
5	(4:2)	(2:4)	(2:1)	(-2, +2, -1)
6	(1:2)	(4:4)	(0:0)	(0, 0, 0)
7	(2:5)	(2:0)	(2:3)	(+1, -2, +1)
8	(0:0)	(2:4)	(1:1)	(-1, +2, 0)
9	(1:0)	(2:4)	(1:1)	(-1, +2, 0)
10	(0:0)	(2:4)	(1:1)	(-1, +2, 0)

Table 16: Individual AC Results for the Bad Ending

Participant	Positive (Pre:Post)	Negative (Pre:Post)	Neutral (Pre:Post)	Total Tally (Positive, Negative, Neutral)
11	(0:1)	(2:3)	(0:0)	(0, +1, 0)
12	(0:2)	(2:5)	(3:0)	(-1, +3, -3)

In terms of the individual results, the effect of the game remains the same as the first round of results. However, compared to the first round of tests, there was an increase in more positive outlooks after playing the game as compared to more negative outlooks.

Looking at the comparison between those who picked the good end versus the bad end, surprisingly, there was an increase in positive adjectives for those who played the bad end in the post test. However, with only two cases of this, we cannot conclude whether or not the bad end has anything to do with these results.

For those who went through the good end, the results were as expected for the most part, with either an increase in neutral and/or positive adjectives or a decrease in negative adjectives

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Similar to the first round of results, the participants' scores in the Heuristic Evaluation of Playability (HEP) survey were converted to percentages. The tables below show the data obtained from the test.

Table 17: **Second Round of HEP Results**

	Gameplay (%)	Game Story (%)	Mechanics (%)	Usability (%)	Overall (%)
1	100.00	96.67	94.44	94.44	97.06
2	100.00	100.00	88.89	94.44	97.06
3	91.67	90.00	83.33	100.00	91.18
4	83.33	83.33	100.00	94.44	88.24
5	75.00	63.33	61.11	66.67	67.65
6	83.33	86.67	66.67	72.22	79.41
7	66.67	80.00	50.00	55.56	65.69
8	84.72	70.00	88.89	83.33	80.39
9	97.22	100.00	77.78	100.00	95.10
10	72.22	73.33	77.78	77.78	74.51
11	69.44	70.00	72.22	88.89	73.53
12	94.44	93.33	88.89	100.00	94.12

Table 18: **Second Round of Summarized HEP Scores**

Test	Mean (%)	Std. Deviation (%)
Gameplay	84.72	30.06
Game Story	83.89	30.81
Mechanics	79.17	26.65
Usability	85.65	31.80
Overall HEP	83.66	29.35

The results above show that the game is still very much lacking when it comes to its mechanics. Other aspects of the game, such as its narrative and gameplay also require further work to make the game more playable.

## 5 Conclusion

### 5.1 Effectiveness in Changing Attitudes

While the video game was able to positively affect the participants' view towards the police, as well as their levels of social empathy, the results were found to be insignificant. This means that there may be other factors which caused this change. As such, the game cannot be held fully accountable for any changes in the participants' scores.

### 5.2 Mechanics and Game Elements

Though the game was not solely responsible for the positive changes in the participants' views towards the police. The game's elements and mechanics may have contributed to these changes. Therefore, it can be concluded that while improvements can still be made regarding the game's mechanics and elements, the current version may be headed in the correct direction when it comes to representing the struggles of the poor in the Philippines.

### 5.3 Playability

The main issue with the game's mechanics had to do with the game's original key bindings, which the participants found unnatural. While a key binding option has already been implemented, most participants used the original key bindings, which may have resulted in the game mechanic's low score.

Some common complaints regarding the gameplay had to do with the concept of "fun" and the game's pacing. While most players gave the game a high rating in these two items, some players gave it fairly low ratings. This may be due to a difference in the players' preferences or the game's repetitiveness. Since the alternate mode is focused solely on object and guard interactions, the players may have found it boring.

Regarding the game's narrative, the main issue had to do with the game's ability to trigger an emotional response. While most of the players' ratings for this survey item were high, a few players rated it low. Players also stated that the game's aesthetics were a bit lacking when it came to triggering an emotional response.

Overall, the game still needs further improvement to reach the 85% mark..

### 5.4 Issues

During the testing phase, the researchers avoided giving instructions to the participants. Instead, they were allowed to learn the game's controls and mechanics by themselves.

While this did not affect the results of the SEI and AC, it did influence the game's HEP scores, as most participants skipped the instructions screen and the settings screen. Though the game does provide instructions in all stages, the controls were mostly learnt in the game's main mode. As such, there were a few participants who were confused in the beginning.

### 5.5 Recommendations

One major improvement which can be made to the game's alternate mode is the addition of puzzles or minigames. Currently, only object and guard interactions are allowed. This may have caused players to feel that the game is repetitive and, therefore, not fun.

Aside from this, future improvements to the game can be made by using more Philippine assets and adding artwork to the cutscenes. The game's original controls may also be modified to make it easier to learn and more natural.

Regarding the game's testing, participants should be split into two groups before playing in the future. There should be a set number of participants for both the good ending and the bad ending so that sufficient data can be collected for both groups.

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# ***KaChow! Food Delivery Service***

## A Virtual Reality Delivery Simulation Game

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### **ABSTRACT**

Delivery services have long been present in many large metropolitan areas to facilitate the delivery of both essential and non-essential goods. With the emergence of the COVID-19 pandemic in 2020, people's dependence on these delivery services have increased substantially. Despite the need for these services, however, the riders who deliver the needed goods still experience disrespectful treatment in the form of scams, fake bookings, and rude and impatient customers. This study aims to raise empathy and awareness of the hardships these riders face on the job, particularly in a country like the Philippines, where the road infrastructure, rules, and regulations are not foolproof, and where the study is mainly based on. The researchers will attempt to achieve this goal by developing a 3D virtual reality game that immerses and allows the player to assume the role of a food delivery rider. Surveys will be conducted before and after playtesting to track changes in testers' knowledge, awareness, and empathy towards delivery riders, as well as to determine the overall fun and enjoyment of the game.

### **CCS CONCEPTS**

• Computer graphics → Applications → Computer uses in education • Personal computing → Games

### **KEYWORDS**

Food delivery, simulation games, educational games

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## **1 Introduction**

### **1.1 Context of the Study**

The need for delivery services in the Philippines has risen since the outset of the COVID-19 pandemic in March 2020 [12]. Encouraged to stay in their homes to minimize the spread of the virus, people have become dependent on delivery services such as Grab to obtain essential products such as food and groceries [12]. Behind the success of such deliveries are the delivery riders who have persisted with their jobs in order to secure a better life [22]. A problem thus arises when these riders are met with mistreatment. ABS-CBN News reported of such mistreatment on two separate occasions in September and October 2020, both involving around 10 food delivery riders who fell victim to scam orders in Las Piñas [6][5], the value of the orders reaching as high as ₱20,000 [5].

While customers are generally kind and respectful towards the riders, customers' habits of tardiness in collecting their orders or other minor causes for delay also contribute to a rider's frustrations. In an interview conducted by the researchers with 4 individuals, all males aged 27 to 35, with experience in motorcycle delivery, one member expressed that when a recipient was ready to receive their package prior to his arrival, "*sobrang laking bagay [na] nun*" (it was such a big thing already)<sup>1</sup>. This was in response to a question about what helped them accomplish their deliveries when they encountered difficulties in the delivery process, which they said was already grueling enough.

The delivery process is initially believed to be "easy" to those who do not work full-time as delivery riders themselves. Another individual from the aforementioned interview has stated that the respect he felt toward the full-time delivery riders grew after he went through the delivery process himself, emphasizing that the actual job needed effective multitasking to properly carry out the delivery<sup>1</sup>. He mentioned factors to take note of such as the routes, the traffic enforcers, the package they are delivering, and the risks of motorcycle driving, among others<sup>1</sup>. A major factor that greatly affected their delivery experience was fatigue caused by other factors such as hunger, thirst, and the heat of the day<sup>1</sup>.

### **1.2 Research Objectives**

The developers will create an immersive game that captures the general day-to-day experiences of delivery riders on the job, in order to make players more aware of the difficulties

these riders face on the road and to encourage them to treat riders with more respect.

### 1.3 Research Questions

This thesis aims to answer the following questions: (1) What game elements can be used to represent delivery riders on a job? (2) How can virtual reality be implemented in the game to improve player immersion? (3) How effective is the game in increasing one's empathy towards the delivery riders? (4) How fun is the game?

### 1.4 Scope and Limitations

The game will be built using Unity version 2020.2.7 for computers with Intel Core i5-4590/AMD FX 8350 equivalent or better, NVIDIA GeForce GTX 1060, AMD Radeon R9 480 equivalent or better 4 GB RAM or more [30], and running Windows 7 and above. Virtual implementation will use VR (Virtual Reality) Desktop hardware and will be tested with an HTC Vive set-up.

The game's geographical scope is in the Metro Manila region. The gameplay experience to be portrayed is that of a Metro Manila food delivery rider. There are other delivery services available in Metro Manila but the scope of this thesis is narrowed down to strictly food delivery.

The game would also be portraying road factors mimicking Metro Manila conditions like traffic, road regulations, etc. Scenarios in the game will be based on data to be found in stakeholder interviews.

The data that will mainly be used are from interviews with food delivery riders from Metro Manila. Questions involve their day-to-day experiences during their deliveries. An extensive interview will also reveal what realistic scenarios can be portrayed in the game to ensure the validity of the experience.

Other sources of data include news articles about events involving these food delivery riders. These articles reveal not only second-hand insights of the different experiences of delivery riders but also other information that will help inform the direction of the game.

The target audience of the game will be people of ages 13 and above. The minimum age limitation for VR gaming is around 12 to 13 [8], depending on the headset manufacturer's hardware [17]. HTC has no specified age restrictions but warns its users that young children should not use the headset at all [17].

### 1.5 Significance of the Study

The demand for food delivery services has increased greatly, especially during the COVID-19 pandemic. Many people rely on these deliveries (to buy groceries, for example) in order to stay safe in their homes and minimize their time spent outside [15]. While most of the customers and riders maintain a friendly, professional relationship during the time of delivery,

there still exists instances wherein customers fail to show up to receive their order or suddenly cancel their delivery after the riders have already paid for the customer's order [19].

This thesis will provide an opportunity for players to put themselves in the shoes of the riders they are depending on for their food deliveries. The game will present a delivery rider's experience in a fun and immersive manner. The researchers hope that players of their game treat delivery riders more kindly during interactions with them, which could improve the riders' overall well-being.

## 2 Review of Related Literature

The purpose of this review is to give a detailed background on motorcycle driving and delivery in the Philippines, particularly in Metro Manila, look into virtual reality as a medium for immersive experiences, and explore video games that incorporate the delivery process as the core gameplay mechanic. Furthermore, this exploration will look into possible game frameworks that will aid in the design and development of the video game experience.

### 2.1 Motorcycle Driving and Delivery in the Philippines

#### 2.1.1 Motorcycle Driving in Metro Manila

From 2010 to 2015, the National Capital Region saw an increase in the number of registered motorcycles (and tricycles), from around 600,000 units in 2010 to around 700,000 units in 2015, with motorcycles and tricycles showing increasing overall growth compared to other registered vehicles [7]. As such, motorcycles have grown to become a widely used form of both private and public modes of transport, the latter pertaining mostly to services such as GrabBike or Angkas, which are wireless mobile applications developed with improvements in information and communications technology [7].

##### 2.1.1.1 Common Traffic Rules

**Speed Limit.** According to Republic Act No. 4136, which is an act that compiles laws relative to land transportation and traffic rules, Chapter IV, Article I, Section 35 (a) in summary states that "[a]ny person driving a motor vehicle... shall drive the same at a careful and prudent speed... [so as not] to endanger the life, limb, and property of any person..." [1].

**Overtaking and Passing a Vehicle.** According to Chapter IV, Article II, Section 39 of RA No. 4136, the general rule regarding overtaking states that "[t]he driver of any motor vehicle overtaking another vehicle proceeding in the same direction shall pass at a safe distance to the left thereof..." [1].

**Right of Way and Signals.** Chapter IV, Article III, Section 42 (a) states that "[w]hen two vehicles approach or enter an intersection at approximately the same time, the driver of the

vehicle on the left shall yield the right of way to the vehicle on the right, except as otherwise hereinafter provided" [1].

**Reckless Driving.** Under Chapter IV, Article V, Section 48 of RA No. 4136, the law on reckless driving states that "[n]o person shall operate a motor vehicle on any highway recklessly or without reasonable caution... so as to endanger the property or the safety or rights of any person or so as to cause excessive or unreasonable damage to the highway" [1].

**Driving While Under the Influence of Liquor or Narcotic Drug.** Section 53 of the same chapter and article as noted above in RA No. 4136 states that "[n]o person shall drive a motor vehicle while under the influence of liquor or narcotic drug" [1].

**Driving or Parking on Sidewalk.** Still in the same chapter and article as the miscellaneous traffic rules listed above is Section 52, which states that "[n]o person shall drive or park a motor vehicle upon or along any sidewalk, path, or alley not intended for vehicular traffic or parking" [1].

#### 2.1.1.2 Rider Characteristics and Behavior

A study was released in 2011 detailing the characteristics and behavior of riders using statistical data obtained from surveys for both riders and non-riders alike. From this study, a quick overview of motorcycle training and experience, riding habits, opinions on road safety, and results from anger and aggression tests will be tackled in the succeeding paragraphs.

**Training and Experience.** The study shows that 90% of respondents have taken an actual licensure examination and 68% have confirmed their exam to include an actual test ride [23]. This means that those who were not required for a test ride is still relatively high at 32%. Another variable to take note of is that 62% of respondents have not received any formal training in riding [23].

**Riding Habits.** On the use of headlights, about 53% confirmed using them even during the daytime for 50% of the time [23]. On the use of helmets on the other hand, which is required by law according to Republic Act No. 10054 [3], a good 78% of respondents confirmed to always wear their helmet when riding their motorcycle [23]. On the use of signal light, only 20% have admitted to doing this occasionally, which is less than 50% of the time [23]. Additionally, a significant 73% ride their motorcycle when tired and 48% admitted to riding under the influence of alcohol at least less than 50% of the time [23]. The act of lane splitting, which is prohibited by law according to an order from the Land Transportation Office, particularly outlined in Administrative Order AHS-2008-15 [2], about 73.80% have confirmed to doing this [23]. Another 62% misjudge the speed needed to maneuver around bends in the road [23]. 52% have also said to overtake other vehicles over the allowed speed limit and 71.32% have said to overtake more than two vehicles [23].

**Opinion on Road Safety.** The study has summarized that the top 3 most important safety measures for riders among those they have surveyed are (1) regular maintenance, (2) wearing of helmet and other protection, and (3) no riding under the influence of alcohol [23]. On the other hand, the top 3 least important safety measures are (1) driving when tired, (2) prohibition of motorcycles along major roads, and (3) having exclusive lanes for motorcycles [23].

**Anger and Aggression Tests.** These tests were conducted to determine possible initiators for road crashes [23]. The anger test involved presenting the respondents with scenarios and asking them to rate how much anger would be provoked if they were placed in that situation. The aggression test, on the other hand, involved presenting the respondents with statements and asking them to indicate how characteristic or uncharacteristic the statements are in terms of describing them. Results for the anger test showed that other road users generally have a higher anger score compared to motorcycle riders, while results for the aggression test showed that the average aggression score for motorcycle riders ranked lowest among other road users [23]. These results together would imply that motorcycle riders, more than feeling anger and expressing aggression themselves, are exposed to other road users who would exhibit these traits more rapidly in comparison [23].

#### 2.1.2 Motorcycle Delivery Services in Metro Manila

Delivery services such as Grab and Angkas have grown in popularity throughout the years, perhaps attributed to the convenience appreciated by its users [7]. In a study released by Asian Development Bank in 2020, the researchers of the study have conducted informal interviews with random riders for Angkas, a motorcycle taxi service. From these interviews, the researchers have learned that most Angkas riders are not full-time or regular employees [7]. They usually have regular jobs and drive for Angkas during their free time to supplement their existing income [7]. For GrabFood riders as well, some riders work full-time while others do part-time [22].

However, GrabFood riders experience a time-consuming and costly manner of deliveries, claiming that they follow a system that requires them to queue, order, and pay first on behalf of the customer [7]. Many articles and social media posts from netizens highlight the distress of these riders when a customer cancels their order or when they realize they have been scammed. For instance, in a Twitter thread posted by The Philippine Star last April, a food delivery rider was shown to shed tears after his customer cancelled the order he had already paid for. The time of his delivery was around 1:40 AM in the morning. In the video attached to the thread, the rider could be heard saying, "[n]agtatrabaho tayo ng maayos eh" ([w]e're already working properly) [21]. This shows that there are a handful of people who pull off scams or fake bookings without regard for the riders delivering the food items.

## 2.2 Virtual Reality

### 2.2.1 General

In a study that explores the benefits of virtual reality gameplay, Lee, Hsiao, and Chen were able to distinguish different beneficial and sacrificial factors to the user. The beneficial factors are flow, spatial presence, and relaxation. According to the study, flow is defined as the “state of optimal pleasure that occurs when people concentrate on an activity”. Spatial presence is defined as the “experience of believing that they have been transported elsewhere”. While relaxation is defined as the “extent to which users perceive themselves as experiencing a low state of tension” [16].

### 2.2.1 Fields such as Medicine and Education

Virtual reality may not be limited to simply just playing games but may be used for different purposes. One study investigated how surgical simulators can reduce the errors of users in real life surgeries. Using a computer-generated simulation, novice surgeons and residents could afford mistakes on virtual patients and to learn from these mistakes [13]. The future goal of the study is to improve medical screening, training, and education of residents who have surgical tasks in their respective fields [13].

A review of 135 proposals on serious games within virtual reality tackles how effective using them are on knowledge and skills acquisition. Serious games are learner-centered in terms of education. Hence, trainees will be the ones in control over their amount of knowledge acquired and pacing in a serious game. The review also pointed out that using serious games with VR brought about greater student motivation compared to traditional learning approaches, relayed visual knowledge better, and helped students learn more extensively about concepts that were taught to them through traditional teaching [10].

## 2.3 Portrayal of Motorcycle Driving and/or Delivery Services in Video Games

This section explores video games that have motorcycle driving and/or delivery services incorporated as a central theme. These titles explore motorcycle driving and/or delivery services as a mechanic in gameplay as well as a theme in its world.

### 2.3.1 The Uber Game

*The Uber Game* is an interactive news game that puts the player into the shoes of a full-time Uber driver. It uses structured data compiled from driver interviews to construct an economic model that underpins the game, and anecdotes from drivers' experience to construct the scenes encountered by the players.

*The Uber Game* has been a source of education for people. There are organizations using this game to teach

children and students the importance of managing finance as well as to allow them to reflect on the game. This can result in a healthier working relationship between the delivery riders and the customers in general [25].

### 2.3.2 送外卖模拟器 Delivery Simulator

*送外卖模拟器 Delivery Simulator* is a game wherein the player acts as a delivery rider. The player has to deliver a product from the merchant to the customer, and their goal is to make the most amount of money in the shortest amount of time. The player will get the order from the restaurant and deliver it to the customer that has ordered the food. The game also has a penalty system that will dock the player more money depending on how much they exceeded their expected delivery time [31].

## 2.4 Energy/Resource Management in Video Games

### 2.4.1 The Sims

*The Sims* implements an energy mechanic in the game. The player's avatar in the game has a specific amount of energy that decreases when they are awake. The energy of the avatar can only be replenished by sleeping in the game. *The Sims* also implements “energy moodlets” that show the player the avatar's current emotions and mood. This also affects the avatar's energy depletion and recovery [27].

### 2.4.2 Stardew Valley

*Stardew Valley* also implements an energy mechanic that hinders the player's movement and abilities when it reaches 0. When faced with this phenomenon called “Exhaustion”, the player will receive a notice saying, “[y]ou feel sluggish from over-exertion.” The player's movement speed will then be significantly reduced and Fishing Poles can no longer be cast. Sleeping will restore the player's in-game energy [28].

## 2.5 Implementation of VR in Video Games

### 2.5.1 Neko Atsume VR

*Neko Atsume VR* features an in-game tablet that is used as the main hub of the game wherein the player can access most of the game's various mechanics, such as the picture-taking mechanic, through different applications. The tablet can be held and traversed by the controller [11].

### 2.5.2 Sea Hero Quest VR

*Sea Hero Quest VR* implements a map to help navigate the game's world. There is also speed and directional movement in the game that demonstrates how VR controls can work to facilitate movement and acceleration. In the game, the player will determine the direction to which they will steer the boat, and tapping the controller will move the boat via the specified

direction. Holding down on the controller will make the boat accelerate [4].

### 2.5.3 Star Trek Bridge Crew

*Star Trek Bridge Crew* implements tapping controls using visible hands in the VR environment. It shows how a player can interact in the game using hand positions and controller inputs. It shows virtual hands that the player can control. These virtual hands track the controllers that the player is holding. The player can position these virtual hands over an in-game panel in front of the player. The player can then use the controller button/inputs to click on a certain part of the interface depending on the position of their virtual hands [29].

## 2.6 Summary and Final Decisions

A summary of the above literature and the decisions to be taken by the developers will follow in the succeeding paragraphs.

### 2.6.1 Incorporating Common Traffic Rules and Associated Hazards

The common traffic rules listed under subsection 2.1.1.1 will be implemented in the game, as well as the hazards and difficulties associated with these rules as experienced by riders on the road. This decision aims to educate players on the common traffic rules that should be observed while driving as well as the different behaviors exhibited by other riders or drivers on the road. This aims to enhance the players' immersion with the game as most of the gameplay is centered around the actual road delivery experience.

### 2.6.2 Developing the Game in Virtual Reality

The game will be developed in virtual reality precisely because of the beneficial factors enumerated under section 2.2.1, particularly flow, spatial presence, and relaxation. Additionally, the success of virtual reality as a means of education makes it suitable to use as a means of immersion so that players are able to empathize well with the characters they are playing as. This is also effective in teaching the players the common road rules as mentioned above for their level of engagement with the game will be very vivid and realistic.

### 2.6.3 Final Gameplay Mechanics Considered

The developers will be taking the game's core mechanics from both *The Uber Game* and the *送外卖模拟器 Delivery Simulator* game in particular, due to the fact that they are both delivery simulation games by nature. Starting with *The Uber Game*, the developers will be taking note of its scenario-based decision-making to fully immerse the player and allow them to realize that there are actual stakes involved in the choices they are making. Another feature the developers will be taking from *The Uber Game* is the end-of-day summary feature wherein the player's daily earnings will be shown

alongside the daily goal to determine whether or not the player was able to achieve this goal.

The *送外卖模拟器 Delivery Simulator* game makes use of an open world that allows players to ride a motorcycle in. The developers will be incorporating this feature as this adds to player immersion; the player is able to see where they are going as well as how they are going about travelling to their destination. It also includes the particular aspects of the delivery process from getting the food from the restaurant to delivering it to the customer. Since the heart of the developers' delivery simulation game lies in the actual road delivery experience, this open world motorcycle control and delivery feature is non-negotiable. The developers will also be implementing a penalty feature similar to the game's penalty feature, wherein exceeding an expected delivery time will incur deductions from the player's daily earnings.

The developers also aim to implement the energy management mechanic that can be found in games like *The Sims* and *Stardew Valley*. In both games, the player's avatar character will experience drops in energy which can be replenished by actions such as resting or eating, depending on the nature of the fatigue. In the delivery simulator game, player movement will then slow down, and the rider will become more prone to accidents. To be implemented as well are the "energy moodlets" particular to *The Sims*, specifically how they affect the avatar's energy depletion and recovery, either speeding up or slowing down the process depending on the mood.

As for the phone system where the players can access the navigation and delivery apps, the developers will be implementing this system similar to how the tablet system was executed in *Neko Atsume VR*. Similar to this game, the phone interface in the delivery simulator game will not be permanently shown on the HUD of the player to reduce clutter and distractions during playtime. This also contributes to realism within the game because delivery riders do not necessarily stare at their phones the entire time while driving.

Similar to *Sea Hero Quest VR*, on the other hand, the developers will also be implementing a map or navigation feature as constantly mentioned in previous paragraphs. However, instead of having the map being only accessible at the start and having the players memorize the route like how it was executed in *Sea Hero Quest VR*, the delivery simulator game will allow players to access the map or the navigation application any time. This effectively simulates real-life rider behavior wherein they usually glance down at their screens to check with the map if they are following the right route. This also eliminates the need for the player to memorize the route; simply familiarizing themselves with it should be enough, then they can always check again when they need to confirm the directions.

Lastly, in terms of player controls, *Sea Hero Quest VR* as well as *Star Trek Bridge Crew* will serve as references for the developers. Just like in *Sea Hero Quest VR*, the developers

can make use of the tap and hold controls to facilitate movement and acceleration. In *Star Trek Bridge Crew*, similar tap and hold controls were also implemented, along with visual cues in the form of virtual hands to track player hand movement. This implementation can be applied to the motorcycle controls involving the handles, ignition, and meters that riders usually monitor while driving. By including visible virtual hands, the player will be able to see how they can interact with the in-game environment.

## 3 Methodology

### 3.1 Design

#### 3.1.1 Intended Experience

The intended experience is a realistic and immersive one for the player. This is done by using virtual reality as the main platform and by showing scenarios within the game that are similar to what real delivery riders go through in real life. These can be seen with the need to use a mobile smartphone, the vehicles that surround the player, the replication of environment conditions, and the health system of the player. Aside from being realistic and immersive, the experience should also be enjoyable and require enough decision-making to encourage replayability.

#### 3.1.2 Pre-Development Data Gathering

To gather pre-development data, interviews with motorcycle riders who had prior delivery experience were conducted. Their responses from the interview were taken into consideration to help build realistic scenarios for the game. Furthermore, research about common traffic rules and regulations was conducted to gain a more realistic view of what exactly happens on the road. Additionally, a short interview with a GrabFood delivery rider was conducted as well to gain more insights into the nature of their work. Data about how the mobile application works and how their working hours go was obtained.

### 3.2 Development

#### 3.2.1 Hardware and Software

The hardware used will include the HTC VIVE and a desktop computer. The HTC VIVE comprises of the VIVE headset and the VIVE controllers. The desktop computer's minimum requirements are an Intel Core i5-4590/AMD FX 8350 equivalent or better, NVIDIA GeForce GTX 1060, AMD Radeon R9 480 equivalent or better 4 GB RAM or more [30]. The software to be used will include Unity as the game engine, GitHub for version control, Notion for project management, and Figma/FigJam for UI design and brainstorming ideas.

#### 3.2.2 Development Cycle

The Scrum development cycle will be used for the development of the game. The development process will be divided into several sprints where each sprint will focus on a single module of the game. Feedback will be given per iteration and the needed changes to accommodate this feedback will be done per iteration as well.

### 3.3 Testing

#### 3.3.1 Playtesting

Playtesting will be done by volunteers 18 years old and above. This gives the developers a wide range of testers who can give the most relevant input. Playtesting is to be done inside the Ateneo de Manila University campus, if allowed by the quarantine restrictions in place due to the pandemic. Ideally, playtesting is to be done during the 2021-2022 academic year.

#### 3.3.2 Post-Development Data Gathering

A survey collecting initial knowledge of how delivery riders do their work will be conducted for the playtesters. This is for obtaining data on awareness and how informed the players are about the hardships and work that food delivery riders experience. Another survey containing questions on the potential increase in knowledge, awareness, and empathy towards delivery riders will be conducted after testing as well to determine how effective the game was in achieving the developers' goals. This survey will also include questions measuring the playtesters' overall fun and enjoyment of the game.

## 4 Development Progress and Playtest Results

### 4.1 Current Implementation of the Game

The game is currently undergoing development at the time of writing, but a testable PC prototype is available where players can drive through a fictional city to simulate the basic mechanics and look-and-feel of the game. The core gameplay and tutorial are the current primary priorities of the developers, with the storyline and additional difficulty features (i.e. traffic) to be implemented later on.

#### 4.1.1 Prototype Scenario and Mechanics

Prior to implementing the missions as mentioned in Appendix A, the prototype presents the player as a newly hired delivery rider in the city, making use of a friendly "mentor voice" to facilitate the tutorial and the introduction of the mechanics throughout the game.



Figure 1: Introductory Dialogue to the Prototype

The mechanics currently implemented in the prototype include the ability to accept orders through the food delivery application, a navigation system via a minimap, and the player's health system. The prototype also introduces the four different kinds of customers the player can encounter throughout the game. Since the current version of the prototype only aims to test the core mechanics, the only winning condition so far is to complete all four deliveries.

## 4.2 Playtesting Proper

In order to gather feedback on the current version of the prototype, the developers have conducted quick 30- to 45-minute playtesting sessions with five volunteers outsourced from Facebook and Discord. As the current prototype is initially developed for PC, the developers have opted to conduct online playtesting sessions to abide by the quarantine restrictions in place as a result of the COVID-19 pandemic. The results of these sessions will be discussed further in the following subsections.

### 4.2.1 On Gameplay

#### 4.2.1.1 General Feedback

A majority of the testers have commented that the game and its premise was interesting and fun. One tester commented that she liked the health system mechanic. Overall, they were able to visualize what the final version of the game would look and feel like based on what they played through in the prototype. However, they have also brought up certain points for improvement which will be elaborated further in the following subsections.

#### 4.2.1.2 Map and Navigation

One of the biggest causes for confusion for the playtesters is the current navigation system, which is presented as a minimap.



Figure 2: Navigation System with a Red Blip Representing the Customer, a Green Blip Representing the Restaurant Direction (Left), and a Blue Blip Representing the Customer Direction (Right)

While some testers were able to find the locations of the restaurants and the customers with little to no problems, a majority of the testers found the system confusing to use. Particularly, they noted how the positioning of the green and blue blips is relative to the point-of-view of the player, with one tester noting that it works very similar to a compass. As a result, the constantly changing position of the green and blue blips made it difficult for some of the testers to pinpoint the correct direction they have to follow to reach their destination, which resulted in players getting lost and being unable to find their destinations without assistance from the developers. Additionally, one tester also noted that she wasn't sure if she was getting closer to her destination or not.

#### 4.2.1.3 Player Health System and Food Health Bar

The second source for improvement stems from how the health system was implemented. While a few testers were able to notice the blinking red icons that appear on the right-hand side of the screen whenever a certain aspect of their health needs attention, a majority of the players missed these icons completely.

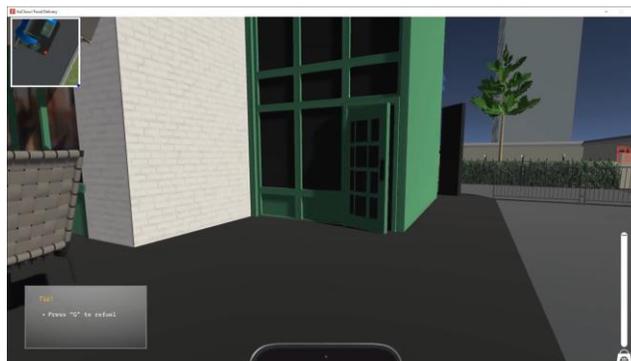


Figure 3: Game Screen with Red Blinking Health Icon

They noted how the current icons used and their placement on the screen make them difficult to notice. Additionally, some testers were also unsure as to whether or

not the replenishing and refueling mechanic was successful in addressing the player's hunger and low gas levels, respectively. In terms of the food health bar, which is the white bar on the lower right side of the screen in Figure 3, many of the testers have mistaken it for the gas meter instead.

#### 4.2.1.4 Other Notable Comments

Navigation and health systems aside, a tester has also commented that the phone itself felt intrusive to the gameplay experience.

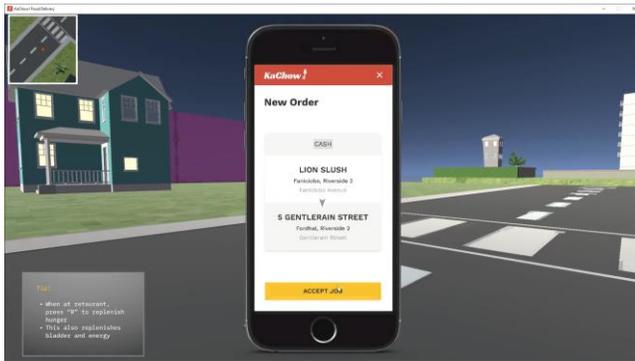


Figure 4: Player Phone with Food App Opened

Another tester suggested placing the phone somewhere to the side so it does not completely obstruct the players' view. Additionally, a number of testers have also noted that they would like to see how the different types of customers would respond in dialogue, and on the other hand, that they thought it would be interesting to see the customers' order lists as opposed to a generalized, pixelated order list.

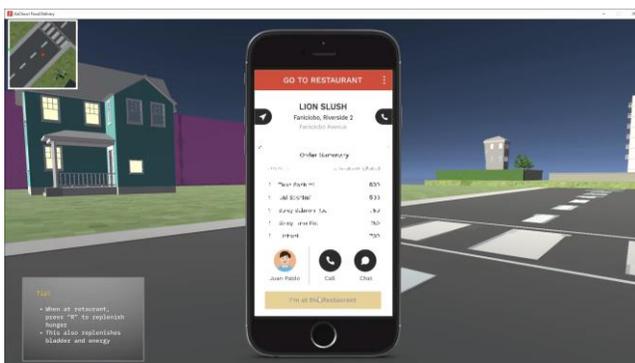


Figure 5: Pixelated Order List

One tester also mentioned that he enjoyed the references to real-world restaurants, and would like to see more of these references in the future if possible.



Figure 6: 'Lion Slush,' a reference to the real-life boba shop 'Tiger Sugar'

#### 4.2.1.5 Measurement of Fun

To quantitatively synthesize the above points for improvement, the post-testing survey given to the playtesters after their session includes a questionnaire that measures how fun they found their gameplay experience to be. The questions in said questionnaire is closely based on the Heuristics for Evaluating Playability [9].

When asked about gameplay, 60% of testers *strongly agreed* that there was a clear goal for them to accomplish from the start. 60% of testers also *agreed* that the challenges presented to them in the prototype made them want to play more to improve and overcome these challenges. However, there were scattered opinions on the effectiveness of the tutorial in teaching them the necessary skills and mechanics to get started, with 40% of testers *disagreeing* on its effectiveness. There were also differences in opinions regarding the penalization of any mistakes made in-game, with 40% of testers *agreeing* that they were penalized fairly while the remaining 60% noted that they felt the contrary. On the other hand, 40% of testers *agreed* that the difficulty was paced well across the four customers, and the same percentage of testers were able to feel that the game world reacts to their actions well. 40% of testers also felt that the game would be enjoyable to replay.

On the other hand, when asked about the mechanics, 60% of testers felt that the controller actions are consistently mapped, easily learnable, and intuitive. 40% of testers also thought that the game worked like any other simulation game.

Finally, when asked about usability, 40% of testers *disagreed* with the statement that the feedback they received from the game for their actions was timely and obvious. 60% of testers were also doubtful of whether or not they had enough information to start playing the game when they first started. 40% of testers also felt that they were not confident to be able to play the game if they didn't have a manual. The interface/HUD also felt intrusive to 40% of testers as they were playing. However, 80% of testers *agreed* that the UI is

consistent in control, color, typography, and dialog design, and 60% of testers felt that the art style and direction of the game were appropriate. Interestingly enough, while 40% of testers did not feel confident playing without a manual, 60% of them still felt that they were given appropriate context while playing so they do not get stuck or have to rely on a manual. This last metric seems to present a conflict in terms of the game's ability to guide players effectively, so it is worth taking note of for future iterations of the game.

#### 4.2.2 On Awareness and Empathy

In terms of whether or not the game was effective in raising awareness about the food delivery riders' job process, there was a significant growth in said awareness from an initial rating of 2 out of 5 according to the pre-testing survey to a final rating of 4 or 5 out of 5 according to the post-testing survey. Players were also able to briefly outline the food delivery process from the rider's perspective, with added insights on the difficulty of multitasking and possible setbacks the rider may experience while on the job.

With regards to the riders' job experiences in addition to the delivery process, the testers were already quite knowledgeable, prior to playing the game, about the different fake bookings and scams these riders experience in addition to the regular kind customers they encounter. As a result, the increase in ratings in this area is minimal in comparison, with an initial rating of 3 or 4 out of 5 to a final rating of 4 or 5 out of 5.

In terms of empathy, the testers are already quite empathetic towards the delivery riders given that they are also already quite knowledgeable about the riders' experiences as mentioned above, so there is no increase in ratings in this area from the initial rating of 5 to a final rating of 5. If anything, the game may have only reinforced their feelings towards the food delivery riders.

### 4.3 Moving Forward

After the first round of testing and feedback from playtesters, the developers will now focus on improving the tutorial stage of the game, which serves as the basis for succeeding iterations of deliveries. Priority will be given to debugging and refining the navigation and health systems as these mechanics received the most points for improvement from the playtesters.

#### 4.3.1 Redesigning the Navigation System

Most playtesters have noted that they would like to see the entire map at once, as opposed to only their immediate surroundings as is the case with the current minimap implementation. Said testers have cited *Stardew Valley* and *Among Us* as references in this aspect, where the entire map is fixed and only the positions of the icons of the players and other relevant agents change according to where they move.

This will be the new implementation the developers will focus on refining for the next iteration of the game.

#### 4.3.2 Improving the Player Health System and Food Health Bar

Since most of the playtesters did not notice the blinking red icons that appear whenever their health system is compromised, the developers will focus on changing the indicators from icons to health bars entirely, since the VR component will not yet be taken into consideration for earlier iterations of the prototype. This has been a suggestion by a few of the testers, with one tester citing *The Sims* as reference. This is so they are able to properly gauge and prioritize which personal needs should be met first, or if it is safe for forgo these needs temporarily to prioritize completing a delivery first. On the other hand, the food health bar will be redesigned accordingly as well so players will not mistake it for any other kind of meter. Circular bars will be implemented for all indicators so as not to take up too much space on the screen.

#### 4.3.3 Other Notable Fixes

There is also a general need to improve the number and quality of feedback provided by the game for player actions, since the testers have made clear in the post-testing survey that the timeliness and obviousness of the feedback have not been apparent. Some players have also suggested adding a sound notification for any new orders that might come in, so players do not have to rely on the solely visual cue of the notification badge to be informed of new orders. Other minor suggestions taken in consideration by the developers include drafting real dialogue responses from the customers in order to add pressure to the players, as well as depixelating the order form to show actual order items. This is because players have mentioned feeling disoriented after seeing the pixelated order form and would simply like to see what the customers are ordering, even if they do not necessarily have to place the order themselves in the game. The placement of the phone from the center to the side is also considered for the next iteration of the game.

Other suggestions proposed by the testers, while important and interesting to consider in order to enhance the overall gameplay experience, will be revisited later on after the basic mechanics have been refined.

## 5 Conclusion

### 5.1 Representation of Delivery Riders Using Game Elements

The game's mechanic of using a food application on a phone to manage orders is the primary element used to illustrate delivery riders on a job. The use of a map to help players navigate around the city is also another primary element

applied in the game. A motorcycle asset was initially planned to be added to the game that included a compartment attached to the back of the vehicle, in which the compartment is designed with the signature *KaChow!* logo and color. This motorcycle with a customized compartment attached is specifically for use for riders working for the fictional *KaChow!* food delivery company in the game, adding to the game's realism factor to more accurately portray the riders as working for an actual company. More details as to why this was not included in the current version of the game are expounded on further in section 5.4.

## 5.2 Effectivity of the Game in Increasing Player Empathy

As indicated in the post-testing survey results elaborated in Chapter IV, the players are already quite empathetic towards the delivery riders even before playing the game. However, since they were also able to learn more about the food delivery process from the rider's end while playing, the game has served to further reinforce their feelings towards the food delivery riders in general. This is because they were able to witness it firsthand through the game that the job of food delivery riders entails a lot of multitasking and adaptability on the part of the rider to be able to accomplish the delivery properly.

## 5.3 Player Enjoyment

To briefly summarize the post-testing survey results elaborated in Chapter IV, most of the testers found that the game would be enjoyable to replay, and that many of them were encouraged to play more to improve and overcome the challenges that were presented to them in-game. Addressing the issues and following the recommendations outlined in the succeeding subsections would effectively maximize the fun of the game to its fullest potential.

## 5.4 Issues

Due to time constraints, the developers were not able to implement most of the features planned for the complete game, such as how weather and traffic might affect player mood and productivity. The current version of the game is also majorly lacking in the narrative aspect, which may have helped players become more empathetic towards the rider they are playing as should the rider have a story or solid motivation for doing his job. Due to the rushed implementation of the core mechanics as well, there are multiple bugs that constantly appear, ultimately taking the players away from the ideal experience they should have undergone with the game.

On the other hand, the motorcycle asset mentioned in section 5.1 was unable to make it to the current version of the game due to time constraints as well. Additionally, many of the planned buildings that referenced real-life establishments

were also unable to make it to the game. These assets, which would have greatly contributed to the realism of the game, proved difficult to obtain. This is because the 3D model artists the developers reached out to for these assets encountered personal difficulties with accomplishing the tasks requested of them. As such, only a few of the buildings have made it to the current version of the game.

Lastly, the developers were not able to implement the VR component because of the COVID-19 pandemic. This limited the testing capacity to a purely online medium, while also making it difficult for the developers to obtain VR equipment as well. As such, the second research question in Chapter I failed to be explored.

## 5.5 Recommendations

Aside from the general bug fixes and the continued implementation of the game to include the other planned features, one major recommendation would be to pursue the VR component of the game. This would be a notable addition with regards to player immersion and fun.

Additionally, another noteworthy consideration would be to reward players with achievements for specific actions, such as accomplishing their delivery under a specific amount of time or taking care of their health system such that no health meter ever reaches a critical point. Such achievements may encourage the player to play more often to improve their skills in order to obtain these achievements. As a result, in addition to educating players on the food delivery process and encouraging them to be more empathetic to food delivery riders, striving for achievements may also help them practice efficiency and see the value of properly caring for one's health even while on the job, among other things. The game thus has the potential to not only help the players learn more about the riders they are interacting with in real life on a regular basis, but also to develop certain perspectives and skills to help them appreciate these riders more holistically.

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# Toxscreen

## A Game for Prevention of Substance Abuse

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### ABSTRACT

The researchers present Toxscreen, a mobile tower defense game designed to prevent tobacco abuse. The game makes use of the Cognitive Behavioral Game Design (CBGD) methodology to encourage the retention of knowledge about the consequences of excessive tobacco use. The researchers compared the results of participants who played the CBGD-based mobile game and used pretest and posttest to determine if the game had succeeded in increasing the knowledge of the participants. The researchers also assessed the playability of the game using a questionnaire adapted from the Heuristics Evaluation Strategy for mGBL. Data analysis showed that the players using the mobile game had higher knowledge after playing the game. Players also enjoyed the game's audio and visual representation, how quick to start the game sessions are, how clear the goals and objectives are, and how understandable the content is.

### CCS CONCEPTS

• Computer graphics → Applications → Computer uses in education • Personal computing → Games

### KEYWORDS

Digital game-based learning, Tobacco knowledge, Health, CBGD

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## 1 Introduction

### 1.1 Context of the Study

Each year, many people die from tobacco exposure. The World Health Organization (WHO) states that tobacco abuse alone causes 8 million deaths each year globally [48]

and 59.1 million disability-adjusted life years (DALYs) in 2002 [46].

Tobacco abuse has affected many lives and not just smokers. Environmental tobacco smoke (ETS), also known as second-hand smoke, is a result of the combination of smoke coming from tobacco cigarettes and exhaled smoke by people actively smoking. ETS exposure can also negatively affect non-smokers, especially children who are not in a position to protect themselves [46]. 15% (1.2 million) of the total deaths from tobacco abuse were from the result of non-smokers being exposed to ETS, according to the WHO.

The medium the researchers have decided to use to convince and educate people about the negative effects and consequences of smoking too much tobacco are video games. While video games are primarily meant for entertainment, they can also offer several benefits to the cognitive abilities of the individual [12].

Another reason the researchers chose video games is due to their rising popularity within the context of modern culture, as many people of varying ages nowadays play video games and identify themselves as gamers [24].

The narratives chosen for the game revolve around the lives of those concerning tobacco affected individuals.

### 1.2 Research Objectives

This research aims to continue another research which focused on educating and dissuading alcohol abuse through the medium of a game [44]. This research aims to cover more substances, in order to educate players about these substances in a fun and engaging manner as they play through the game.

### 1.3 Research Questions

This study aims to answer the following questions: How effective is the game in increasing the knowledge of the user regarding the harmful effects of tobacco?

1. What aspects of tobacco use should be represented in the game?.

2. What game mechanics can be used to represent these aspects of tobacco use?
3. How effective is the game in providing entertainment and fun to players?

#### 1.4 Scope and Limitations

The participants for the study are to be recruited and sampled purposely from a college within Metro Manila, Philippines. The target demographic of this study will be college students. The timeframe of this study will be done within the year 2021 to 2022.

As for the game itself, the drug substance covered will be tobacco. The game's engine will be Unity, the same as the previous game Drug Defense. The game will be also limited to a mobile platform.

This research will also employ Heuristics Evaluation Strategy for Mobile Game-Based Learning [51] in order to measure the game's functionality.

#### 1.5 Context of the Study

As of 2015, the Philippines had around 16.6 million adults who use tobacco. 76.7% of those smokers were interested in quitting but only 4% were successfully able to do so within the year. In addition to this, 24 million adults were exposed to second-hand tobacco smoke at home, therefore indicating potential health risks to family members at home [47].

This research aims to not only inform the public about tobacco but also provide insight into the problems and solutions associated with them. This research is also aimed towards showing the effectiveness of using video games as an educational medium. Computer Science is closely related to video games and this research could provide additional data on how various social problems could be tackled by this field.

## 2 Review of Related Literature

The purpose of this review is to provide a more detailed explanation on tobacco and its effects on the human body, study the framework that will be used to shape the game, define and use the likert scale used to measure data, and to discuss the educational effects of video games and review specific video games that have depicted the use of tobacco and used tobacco as a mechanic in the game. The chapter will begin with a detailed description of tobacco, nicotine, and second-hand smoking, including its effects on the human body, its usage, and treatments for it. Afterwards, the review will focus on the portrayal of tobacco in video games. The concepts of video games as a learning tool were also explored, followed by the Cognitive Behavioral Game Design framework. Afterwards, a general summary of the previous research's game, Drug Defense, is given. Finally the heuristics evaluation strategy for mobile game-based learning is explained in detail.

The researchers will emphasize the effects of smoking on the human body, reflected in the level design and difficulty as the game progresses. The game's design and mechanics are initially similar to the previous research's Drug Defense, while concepts such as treatments for tobacco and how the body metabolizes nicotine are to be used in the game as additional mechanics. The game's design and development will also be influenced by the portrayal of tobacco in similar media, and how video games are utilized as a learning tool.

### 2.1 Tobacco

The game will focus on tobacco and its effects on the human body. The game being developed will show the negative effects of tobacco on the human body, specifically within the lung area, and will introduce ways of stopping or reducing the effects using the combination of medicine and therapy.

#### 2.1.1 Definition of Tobacco

Tobacco originates from several plants within the Nicotiana genus. The product itself is a result of curing tobacco leaves. It contains the highly addictive substance nicotine as well as harmful alkaloids [41]. In the Philippines alone, over 64.4 billion cigarettes were sold in 2018. Being the 15th largest tobacco consumer in the world in 2002, it has some of the highest smoking rates with the lowest cigarette prices [6].

#### 2.1.2 Tobacco Usage

People can consume tobacco in a variety of ways, either through smoking, chewing, or sniffing it [38]. Smoking tobacco acts as a way for certain people to celebrate special occasions or ceremonies. Another way it was used was to relax and bond with friends and family during social gatherings [14]. Smoking tobacco may also be used to relieve stress during difficult situations. People who are currently smoking may have been influenced by family or friends around them at an early age who were also smoking [2]. Media advertising tobacco usage, such as movies or posters that depict smoking, may have also influenced people's decisions to pick up smoking. The youth are vulnerable to social and environmental influence, and as such are more likely to smoke the more exposed they are to this influence [39]. According to the Global Adult Tobacco Survey (GATS), in the Philippines, 44% of adults noticed advertising for cigarettes in stores where they are sold [47].

#### 2.1.3 Tobacco Effects

**2.1.3.1 Nicotine Effects.** Nicotine is the main chemical in tobacco. It is toxic, highly addictive, and a stimulant [2]. It includes pharmacological effects such as increased heart rate, heart stroke volume, and oxygen consumption by the heart muscle as well as psychodynamic effects such as euphoria, increased alertness, and a sense of relaxation [45]. Nicotine may also yield positive effects towards the

aspects of fine motor abilities, alerting and orienting attention, and episodic and working memory [32].

**2.1.3.2 Addiction.** Many people find it difficult to stop smoking tobacco due to nicotine being a very addictive substance. This is especially true for first-time smokers, who are more likely to get addicted to tobacco compared to first-time alcoholic drinkers or cocaine users. Studies also show that first-time smokers who are more likely to become a life-long smoker are those that start smoking when they are teenagers, compared to starting smoking as an adult [2].

**2.1.3.3 Negative Effects on the Human Body.** Despite nicotine being addictive, most of the serious effects damaging to one's health comes from the other harmful chemicals found in tobacco [38]. Most of the time, lung cancer is developed due to tobacco smoking, however it can also cause cancer on almost anywhere in the body, ranging from oral and facial parts such as but not limited to the lips, tongue, mouth, nose, to the organs found inside the body like the liver, stomach, kidney, and pancreas [3][38]. Smoking tobacco can lead to two main types of chronic obstructive pulmonary diseases (COPD), which are a group of lung illnesses that hamper a person's breathing and become progressively worse over time [3][38]. Smoking also increases the risk of heart disease and blood circulation problems, which can lead to stroke or heart attack [3][14][38]. There is also the risk of developing problems with teeth and gums [14]. Pregnant women are also affected as the risk of miscarriage, stillborn, and sudden infant death syndrome is increased when they smoke [19][38]. Chances of premature infants or preterm birth may also increase [19][38].

Second-hand smoke, also known as passive smoking, is also another health hazard to people who are near those who smoke which may come from the person smoking or the burning tobacco itself. This second-hand smoke may lead to both adults and children contracting lung cancer, heart disease, coughing, phlegm, reduced lung function, pneumonia, and bronchitis. Children exposed to second-hand smoke are at an increased risk of ear infections, severe asthma, lung infections, and death from sudden infant death syndrome [1][38].

At worst, tobacco smoking could cause death. 8 million people die from smoking every year in the whole world, and half of the users of tobacco die because of using it [46]. The disability-adjusted life year (DALY) is a measure of the number of years lost due to early death, disability, or poor health. Smoking causes 59.1 million DALYs every year [48].

**2.1.3.4 Tobacco Withdrawal.** Due to the continuous nicotine exposure resulting in addiction, people who smoke

tobacco will find it difficult to quit and may experience withdrawal symptoms. Some symptoms include irritability, restlessness, difficulty concentrating, nervousness, disturbed sleep, increased appetite, and severe longing for tobacco [2][3][14][38].

#### 2.1.4 Tobacco/Nicotine Treatment

There are two main methods of treatment to help people quit tobacco smoking. One is behavioral treatment that provides smoking cessation counseling by a specialist to aid the person to stop smoking. Another method is the use of medication that acts as nicotine replacement or lessened nicotine products that ease people into quitting smoking. Individually, both behavioral treatments and medications can help patients stop smoking. However, the combination of behavioral counseling with medication is more effective than each treatment alone [36][38].

**2.1.4.1 Nicotine Metabolism.** The human body is capable of metabolizing nicotine in order to control nicotine levels. Nicotine is mainly metabolized by the liver enzymes CYP2A6, uridine diphosphate-glucuronosyltransferase (UGT), and flavin-containing monooxygenase (FMO) [13]. The metabolism of nicotine is influenced by genetics, age, sex, use of estrogen-containing hormone preparations, pregnancy and kidney disease, other medications, and smoking itself.

**2.1.4.2 Behavioral Treatments.** Behavioral treatments have an assortment of methods to help patients stop tobacco smoking, varying from self-help materials to counseling from specialists. Health care professionals, in typical clinical settings, have limited time to spend on tobacco addiction cases. However, a counselling session that lasts at least three minutes can increase the likelihood of prolonged abstinence compared to no counselling [31]. For the treatment, there is a "5 A's" strategy that serves as a guideline for clinicians. These five steps are asking about tobacco use, advising to quit smoking, assessing patient willingness to make a quit attempt, assisting the quit attempt with counseling and pharmacotherapy, and arranging a follow-up [4][31]. These treatments also educate people on recognizing high-risk situations and develop strategies to deal with them. One example of a high-risk situation is an environment where people who consistently smoke linger around in. People who remain in that environment are more likely to smoke and less likely to stop [38].

**2.1.4.3 Nicotine Replacement Therapies.** Nicotine replacement therapies (NRTs) were the first medications the U.S. Food and Drug Administration (FDA) approved for use in smoking cessation therapy. Some FDA-approved over-the-counter NRT products are chewing gum,

transdermal patch, nasal sprays, inhalers, and lozenges [36][38]. NRTs deliver a controlled dose of nicotine to relieve withdrawal symptoms while the person tries to quit [38]. Another method is to use bupropion (Zyban®) and varenicline (Chantix®), which are two FDA-approved non-nicotine medications that have helped people quit smoking. They target nicotine receptors in the brain, easing withdrawal symptoms and blocking the effects of nicotine if people start smoking again [38]. Other known medicinal methods include using medication combinations along with the NRT, using antidepressants in addition to Bupropion, and precision medicine [36].

**2.1.4.4 Transcranial Magnetic Stimulation.** A relatively newly approved treatment that is used to help treat tobacco addiction is the transcranial magnetic stimulation. According to the National Institute on Drug Abuse (NIDA), “it is a physiological intervention that noninvasively stimulates neural activity in targeted areas of the brain using magnetic fields”. The Food and Drug Administration (FDA) has approved two repetitive TMS devices for depression treatment in adults [36]. High-frequency TMS treatment has significantly reduced adult smokers’ number of cigarettes smoked when other treatments did not help in their quitting of smoking.

#### 2.1.5 Tobacco Second-hand Smoke

Second-hand smoke is the combination of smoke from the burning end of a cigarette and the smoke breathed out by smokers. Second-hand smoke contains more than 7,000 chemicals. In addition to the dangerous chemicals that smokers inhale, second-hand smoke also contains other harmful substances such as formaldehyde, benzene, vinyl chloride, arsenic ammonia, and hydrogen cyanide.

There is no risk-free level of second-hand smoke exposure; even brief exposure can be harmful to health. Comprehensive smoke free policies have been successful in protecting those who do not smoke, and are the only way to fully protect their health [21]. 8 million people die from tobacco smoke every year, and 15% of these are non-smokers being exposed to second-hand smoke. 1.2 million premature deaths are caused by second-hand smoke while also causing serious cardiovascular and respiratory diseases to people exposed [49].

#### 2.1.6 Strategies to Discourage Tobacco Use

The various medical consequences of tobacco use and second-hand smoke exposure have encouraged communities to find ways to reduce and limit the demand for tobacco.

One way of preventing tobacco usage is by implementing policies. Increased taxation on tobacco products is the most cost-effective way to reduce tobacco

use and health care costs [37][49], but this is the least implemented measure among ways to discourage tobacco use. Another is the implementation of stricter laws regulating who can purchase tobacco and what tobacco products can be bought [37]. Restrictions and bans on tobacco product advertising are also known to lower tobacco consumption. Mandatory, pictorial health warnings on packages that depict tobacco’s graphic negative effects are also a form of prevention, and are known to increase cooperation with smoke-free laws and encourage people to quit tobacco usage [37][49]. Within the Philippines, there are several mobile applications focused on enhancing the health of Filipinos. Among these include Drug Defense, a mobile game aimed to reduce teenage alcohol consumption by increasing adolescents’ knowledge on alcohol use and protective behavioral techniques while reducing their intent to use and actual use [43]. However, there are currently no mobile games that address smoking among Filipino adolescents

## 2.2 Portrayal of Tobacco in Video Games

### 2.2.1 Smoking Depicted in Games

Tobacco use has been widespread throughout various video games played by millions of people. A 2012 study discovered a steady increase in tobacco content within video games rated appropriate for children as young as 10 years old, from the past decade. Between 1994 and 2011, 60 out of 78 large video game publishers have included imagery at least once [11]. Within a 2015 survey, around 42% of the games played by participants were reported to have tobacco content and among these games, only 8% of these games had received tobacco warnings from the Entertainment Software Rating Board (ESRB) [25].

### 2.2.2 SmokeSCREEN

SmokeSCREEN is a game developed by play2PREVENT and 1st Playable Productions [40]. The game addresses the different difficulties teens face with a focus on decision-making about tobacco use while employing strategies for smoking prevention and cessation. The game features a narrative in which the player meets various non-player characters throughout the game that force the player to make in-game decisions about tobacco use. Various information about tobacco and smoking as well is depicted in the game and provided to the player.

Similar to their approach, this research will also use narratives and gameplay as a feature to dissuade and inform players about tobacco abuse. Information and facts about tobacco will also be shared to the players as they progress through the game.

## 2.3 Video Game as a Learning Tool

Video games have the ability to motivate people for deep, new learning in classrooms while achieving recreation at the same time [27]. Good games as stated by Gee are those that function near the outer bound of a player's competence and growing outward, thus learning more while remaining challenging but feasible to accomplish. This frustration of being unable to temporarily clear levels remains pleasant and a good source of motivation. Meanwhile traditional learning methods applied by schools operate at the lowest common denominator [22] which does not invoke the same level of motivation. This ability has piqued teachers of different professions to seek ways to apply games to help people to learn more effectively.

Bandura's [7][8][9] Social Cognitive Theory (SCT) has been used to positively influence people's health behavior through the use of a video game that gave them an overall healthier lifestyle. Participants had increased vegetable and fruit intake, as well as less calorie consumption as an overall result. Baranowski et al. [10] managed to use video games to help patients take better self-care for their asthma and stated that serious video games are a promising form of media-based intervention, however it would still require extensive research as it is a new field. Another research by Srinivasan et al. [42] featured the use of a prototype video game that taught problem solving skills in a three-dimensional space, while having circuit problems be done in a 2D manner. It showed positive results in student engagement and learning, however participants stated that having a meaningful narrative in the game would be better than mindlessly doing objectives.

## 2.4 Cognitive Behavioral Game Design

Starks [43] has agreed that although games have the power to be used for educational purposes other than just entertainment, it is a challenge to blend the educational and entertainment factors. Starks then sought to merge SCT and the theory of Multiple Intelligences (MI) of Gardner [26] together into a new framework called the Cognitive Behavioral Game Design (CBGD), alongside factors for motivation or the enjoyment process. The CBGD is a unified model that guides game designers through a process to turn their games into a learning and motivational experience. The framework's purpose can be summarized as one question: "How does one express these Social Cognitive elements through the mechanisms of Multiple Intelligence elements in a way that facilitates the Enjoyment Process?" [43].

According to Tan et al., [44], a video game designed using the Cognitive Behavioral Game Design (CBGD) and approved using Heuristics to Evaluate Playability (HEP), has shown a significantly higher effect size in knowledge when compared to the video documentary they used as a comparison test.

## 2.5 Drug Defense: A Mobile Game for Prevention of Alcohol Abuse

This research is based on Drug Defense, which is a mobile tower defense game that was designed to prevent drug abuse [44]. Drug Defense focused on alcohol abuse in particular, and this research hopes to cover the scope of tobacco abuse, another addictive substance that is common in the Philippines.

### 2.5.1 Gameplay

The gameplay of Drug Defense takes inspiration from the tower defense genre of games. Players are tasked to defend an objective from incoming waves of enemies by purchasing and upgrading towers and turrets, which are based on enzymes, available from the shop to reduce the enemies' health to zero. In the game, the liver is the main objective to defend, and the goal is to stop its health from reaching zero. Various enemies in the form of alcohol, for example a beer bottle, will show up from an opposite end of the path that leads to the liver, and each time they reach the objective, the liver's health gets reduced. Each turret has a specified cost, and some towers are focused on assisting turrets instead of dealing damage, so proper management of resources and tower placement is important and keeps the game entertaining for players to think and progress through.

Players are represented as a medical apprentice in the game. There is a doctor figure in the game, which acts as a guide to aid the player. The doctor teaches the players about tower defense mechanics, such as buying and selling towers, tower placement, tower upgrades, defending the liver from alcohol-themed enemies, and so on. A stage contains two to three waves, with each wave following a similar flow, for a total of eight stages. The core gameplay has four steps, and is consistent per stage of the game. The game's narrative focuses on nurturing player sympathy and attachment. The journal entries usually depict the character's current state or alcohol use, as shown in Figure 1.

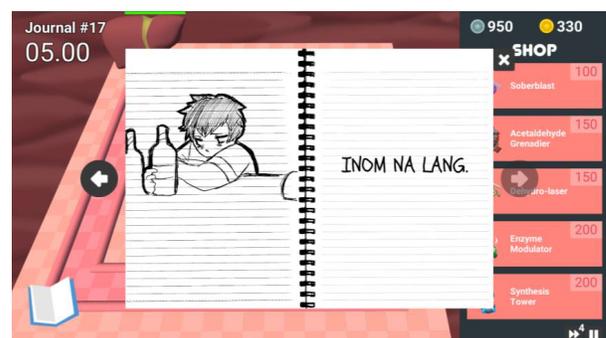


Figure 1: Journal page of the character [44]

### 2.5.2 Testing and Results

The researchers designed and conducted a knowledge retention test to determine the game's effectiveness at increasing the player's knowledge. A total of 69 participants joined the study. All of the participants have drunk alcohol at least once in their life, and are in the age range of 18 to 21. At the start of the experiment, the Alcohol Knowledge Test was completed by the participants, the test containing alcohol use facts, disorder symptoms, and negative physical and cognitive effects of alcohol abuse. The participants are then asked to play through the game, and then sent a Google Form containing the heuristics to evaluate playability questions and open-ended questions related to the game. 56 respondents answered the questionnaire. The participants are then asked to complete the Alcohol Knowledge Test again after one week of them answering the pre-test.

There is a significant difference in the evaluation of pre-tests compared to post-tests, which show that there is an increase in knowledge about alcohol, the research succeeding in its goal of increasing player knowledge. The average of all the heuristics category for the game is 3.89/5, which implies that players were given a pleasant gaming experience from playing Drug Defense.

## 2.6 Heuristics Evaluation Strategy for mGBL

Mobile Game-Based Learning (mGBL) is a learning experience that is centered around games developed for mobile devices [51]. Standard heuristics evaluations have been developed for assessing the efficacy and usability of a software. Because they are focused more on general applications and not on game content, standard heuristics evaluations cannot be used. Therefore the researchers aim to use this heuristics evaluation made specifically for mobile games designed for educational purposes. This heuristics evaluation strategy features four components: Game Usability (GU), Mobility (MO), Game Play (GP), and Learning Content (LC).

GU has ten components that revolve around the look and feel of the game. The audio-visual features and interface of the game must appeal to the player and assist the game in helping the player keep interest in the game until they are done playing with it. Each GU component is described explicitly in Table 1.

Table 1: Game Usability Components

No.	Game Usability Components
GU1	Audio-visual representation supports the game
GU2	Screen layout is efficient and visually pleasing
GU3	Device UI and game UI are used for their own purposes
GU4	Navigation is consistent, logical, and minimalist
GU5	Control keys are consistent and follow standard conventions
GU6	Game controls are convenient and flexible
GU7	The game gives feedback on the player's actions
GU8	The player cannot make irreversible errors
GU9	The player does not have to memorize things unnecessarily
GU10	The game contains help

MO has three components which relate to the aspect of the game being run inside a mobile device, shown in Table 2. The game itself must be ready to be run and paused at any given time, and if a game session is to be stopped midway, the game should be ready to handle this and save the data for the player to resume the game later. It must also be accessible on the go, akin to mobile devices being able to be used whenever and wherever.

Table 2: Mobility Components

No.	Mobility Components
MO1	The game and play sessions can be started quickly
MO2	The game accommodates with the surroundings
MO3	Interruptions are handled reasonably

GP has ten components which detail the game giving meaning and entertainment to the player, while running smoothly and consistently. The GP is essential as it features player interaction with the mechanics and rules of the game. Table 3 shows each GP component in detail.

Table 3: Game Play Components

No.	Game Play Components
GP1	The game provides clear goals or supports player created
GP2	The player sees the progress in the game and can compare
GP3	The players are rewarded and rewards are meaningful
GP4	The player is in control
GP5	Challenge, strategy, and pace are in balance
GP6	The first-time experience is encouraging
GP7	The game story supports the gameplay and is meaningful
GP8	There are no repetitive or boring tasks
GP9	The game does not stagnate
GP10	The game is consistent

The research hopes to borrow aspects from the previous Drug Defense study and add onto it by focusing on tobacco as the next substance abuse to be featured in the game. The same game design framework will be used for Toxscreen, namely the CBGD framework by Starks [43]. The previous heuristics evaluation for playability has been replaced with the heuristics evaluation strategy for mobile game-based learning as it is more recent and specific to mobile games, which is the platform Toxscreen is going to run on. Instead of alcohol, tobacco will be the substance focused in Toxscreen.

Table 4: Learning Content Components

No.	Learning Content Components
LC1	The content can be learned easily
LC2	The game provides learning content
LC3	The learning objective from the game is achieved
LC4	The content is understandable

LC has four components, shown in Table 4, dedicated to the learning aspect of the game. The mGBL experience with the game must impart content to the user that is beneficial, instructive, and comprehensible.

### 3 Methodology

#### 3.1 Aspects of Tobacco Use

The goal of this research is to represent various aspects of tobacco use within the game in order to inform about and dissuade tobacco use. The possible circumstances leading to tobacco exposure such as influence from peers and the addictive nature of tobacco causing repeated tobacco use are to be represented within the game. The various negative effects that tobacco and smoking has on the human body is also to be shown to the participants through the gameplay.

##### 3.1.1 Social Cognitive Elements from CBGD Framework

The researchers aim to use the CBGD framework to design their game. The CBGD framework will also be used to translate aspects of tobacco use into a game mechanic in Toxscreen. There are three categories of elements that will be used. The first type of elements will be from Bandura's SCT that is adjusted for the CBGD's use, which features five elements necessary for health-related behavior changes which are knowledge, goals, outcome expectation, encouragement, and barriers.

Knowledge in CBGD refers to the purpose of the game, the wisdom that it attempts to convey to the players such as smoking's adverse effects and its protective behavioral strategies shown through the journal entries and

conversations. Goals can either refer to the game's actual goals such as defending objectives and defeating enemies, or the real-life result of the game such as applying the game's knowledge to everyday life, or both. Outcome expectations focus on game progression positively or negatively based on the game's genre or style. If a player were to fail a quiz then it would be correct to assume that they will not be rewarded the same way compared to getting the answer correctly. As players are expected to learn facts from this game, rewarding players for incorrect answers would be counterproductive. Encouragement refers to the various factors that can aid in achieving the goal. Praises from characters after getting correct answers is one good example of encouragement. Impediments featured in a game such as enemies that harass the goal or an objective would be called barriers. See Table 5 for how each social cognitive element is applied in the game.



Figure 2: Journal entry in-game.

Table 5: Social Cognitive Elements

Social Cognitive Element	Application in the game
Knowledge	Knowledge regarding the negative consequences of tobacco abuse is delivered by the journal pages and character conversations. Negative effects such as nicotine addiction, COPD, cancer, heart diseases, problems for women during pregnancy, oral problems, withdrawal, and death will be conveyed not only through journal entries and character conversations, but also in the form of protecting the body part at every level.
Goals	The goal is to prevent severe damage to the human body. This is done by either acquiring passive game buffs to help the player at the start of every level, by reducing the number of enemies per level (behavioral treatment) or by using medications in the form of allied towers to attack and lessen the harmful chemicals

	threatening the body part (medication treatment).
Outcome Expectation	Completing a level without meeting the failure conditions unlocks the next level. The failure condition would be letting the current body part reach 0 health due to the harmful chemicals. The body part will depend on the stage of the game. At the start, it may focus around the lungs, specifically around the bronchial tubes and the air sacs found in the lungs, which will be hit by tobacco smoking the most. With each damage taken, the lungs will blacken and become smaller, representing the lungs hardening and being unable to contain a lot of oxygen for the patient, the bronchial tubes will have mucus and will be reddish to represent inflammation, and the air sacs will become less numerous, more deformed, and soggy. If possible, the heart and the blood circulation may also be featured as a body part to defend during the game's progression.
Encouragement	Awarding the player with ingame currency and positive feedback from characters visually and in text format.
Barriers	Various tobacco-themed enemies that damage the human body. Visually, these would be cigarette sticks, a drawing of the tobacco leaf itself, and perhaps drawings of chemicals in red colorations representing the harmful chemical components found in tobacco such as the addictive nicotine, or the harmful hydrogen cyanide, carbon monoxide, and ammonia. Other representations of enemies may be black smoke, to represent not just smoking tobacco, but the damage of second-hand smoke, as well as mucus to show the irritation and inflammation that comes with smoking to the exposed body parts such as the bronchial tubes.



Figure 3: Dra. Tina's feedback to the player's answer.

### 3.2 Tobacco Representation In-game

Tobacco use within the game is to be represented in the game's narrative through the journal system. The main character is to be exposed to various tobacco substances such as first-hand and second-hand smoking. This introduces nicotine into the body, which is then represented in the form of enemies that the player encounters

throughout the gameplay. Due to the addictive nature of nicotine found within tobacco, the main character will use tobacco products more which result in more enemies and difficult levels as the story progresses.

Through in-game dialogue, the character Dra. Tina informs players about tobacco use and also provides quizzes in order to aid in retaining knowledge. She also explains the different mechanics in the game and gives off relevant facts about them.



Figure 4: The doctor giving information to the player.

The enemies are to make their way to the lungs of the level and damage it until the lungs are destroyed. This is a metaphorical representation of the negative impacts of smoking on the lungs. The towers players place are representative of existing enzymes within the body that metabolize nicotine. Once the towers have successfully dealt enough damage to an enemy, that enemy is then metabolized and expelled from the body. As the levels progress, players will be more restricted in their placements of the towers as it is representative of the hazardous effects of smoking on the body. Finally, the introduction of global spells is to represent the possible treatments for tobacco use.



Figure 5: Cigarettes attacking the lungs.

#### 3.2.1 Multiple Intelligence Elements from CBGD Framework

The second type of elements would be elements from the Multiple Intelligence theory. In CBGD, the MI has been repurposed into game descriptions. The MI elements of CBGD that are applicable are graphics, music/sound, narrative, space/positioning, logic/patterns, words/language, math/numbers, and relationship/models, as seen in Table 6, as well as detailed explanations on how each element will be used.

Tobacco usage and its negative effects will be represented by these game mechanics present in the Multiple Intelligence Elements. Graphics represent the graphic elements and pictures in the game, like objects, enemies, characters, signs, and so. These graphics will be designed to depict tobacco products as enemies, enzymes to act as defensive towers that destroy those enemies, and the lungs to depict what the enemies will be after. Music/sound refers to the musical aspect found in a game, be it sound effects, background music, or voiced lines. Narrative is the story element in a game, which allows the player to be immersed in the environment of the game. The story that will be used is of a recovering tobacco user, discussed further in the Game Design Document. Space/positioning details the way a player moves through the game environment visually and spatially. Logic/patterns make use of patterns that involve reason, like using clues or using a combination of game mechanics to pass a certain obstacle. Math/numbers refer to challenges that make use of mathematical problem solving, whether it is the management of currency in game or a puzzle that requires the player to use calculations or geometry. Words/language depicts the use of words and language within games. Relationship/models can refer to the player's relationship with others in a game, or the relationship between characters inside the game.

Table 6: Multiple Intelligence Elements

Music / Sound	Sound effects that play when doing or taking damage. Successfully clearing the level and music that changes based on the body part's health.
Narrative	Story revolves around the player and the supporting character helping people through the practical use of behavioral treatment (buffs that help the player in each level to reduce the number of enemies for example) and the medicinal treatment (represented as towers that damage the tobacco enemies) combined. They may also be recommended to experts as part of the behavioral treatment and to seek counselling to quit tobacco smoking for good. Additional story through the form of the journal pages.
Space / Positioning	Enemies are stuck to one lane, while the player is allowed to place turrets at either side.
Logic / Patterns	There are passive and active game elements to help the player reach the goal. Passive buffs represented as behavioral treatment methods can be bought to help lessen the number of enemies in each level, making the level easier. Medicinal turrets are bought on a per-level basis, requiring the player to place them down each level, otherwise the enemies would be able to pass through unharmed. Some turrets synergize and help other turrets' effects instead of directly doing damage to the enemies.
Words / Language	Conversation in the game from characters is displayed through text boxes, and journal pages may also contain statements of in-game patients.
Math / Numbers	In-game currency is important for spending on and upgrading towers, as well as selling them to increase currency, correctly answering quizzes also gives currency. Passive buffs that help reduce the enemy number will also be available for purchase, although much more expensive as they will be permanent and carry through per level.
Relationships / Models	Characters will form a bond with the players, as well as patients helped, and reading the journal pages helps form an understanding on the characters' lives.

Multiple Intelligence Element	Application in the game
Graphics	The main objective, organ or body part, shaking and changing color when damaged. These would be the lungs, and specifically the bronchial tubes and the air sacs found within. Other body parts that may be featured would be the heart and the blood circulation, which would be the next heavily affected by smoking after the lungs. The more damaged the main objective is, the darker and smaller it will become, to represent the effect of the harmful chemicals damaging the body part and making it smaller, which makes gathering large amounts of oxygen harder for the body part. Medicinal towers shooting projectiles towards the tobacco-themed enemies.

### 3.3 Efficacy of the Game in Dissuading Tobacco Use

This section aims to measure the efficacy of the game in dissuading tobacco usage among users. This is done using pre-test, letting them play the game, then post-test, which will be further explained in the section dedicated to game testing.

#### 3.3.1 Tobacco Knowledge Cognitive Test

This research will measure the participants' knowledge on smoking, attitude on smoking, urge to smoke, and intent to smoke. Knowledge on smoking is defined as the participants' existing knowledge on smoking, its effects, and protective behavioral strategies. This dependent variable will be measured using a knowledge test on smoking that

consists of twenty items containing fifteen multiple-choice questions and five true or false questions.

Table 7 features the twenty questions that will serve as a cognitive test for participants of the study. This test will be applied before introducing players to the game, and then a week after they have finished the game, in order to measure the participants' change in knowledge. These same questions will also be featured in the game. For every quiz segment per stage, there will be two to three questions presented to the player. These quiz questions will either consist of a multiple choice of four different options or a true or false type question. The fifteen multiple-choice items are about facts on smoking and its negative physical, psychological, and social effects [5][15][16][17][20][28][33]. Moreover, the true or false questions are centered on protective behavioral strategies [29][30]. All of the questions will be in relation to tobacco and nicotine.

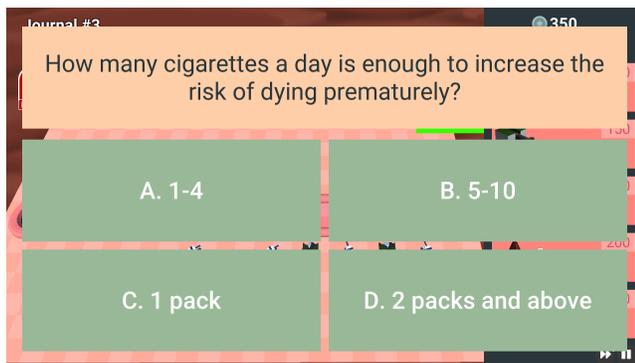


Figure 6: Tobacco knowledge test in-game

Table 7: Sample Cognitive Test Questions

What is the percentage that non-smokers die from tobacco exposure?			
13%	14%	15%	16%
First-time smokers are more likely to get addicted to tobacco compared to first-time alcoholic drinkers or cocaine users.			
True		False	

### 3.4 Efficacy in Providing Entertainment and Fun to Users

This section provides the tools used to measure the entertainment and fun acquired by players while using the game for the researchers to gather information from and create

These will be accomplished by using the Enjoyment Process Elements, as well as the Heuristics Evaluation for mobile Game Based Learning.

#### 3.4.1 Enjoyment Process from CBGD Framework

The final type of elements would be the Enjoyment Process, consisting of engagement, challenge, flow, persistence, and mastery. Engagement features the attention-grabbing aspect of the game that keeps the player interested and engaged. Challenge is the reason or motivation that players need to continue playing the game. Flow is the player's use of prior information to overcome future challenges, as well as giving the player a difficulty curve, starting with easy problems and increasing in difficulty. Persistence allows the player to commit mistakes and learn from them with little to no consequence on the player's life outside of the game. Mastery gives the player satisfaction when a certain game element is mastered or beaten, and the game gets progressively harder in the later stages which provides a challenge to the player. How the enjoyment process is implemented in the game can be seen in Table 8.



Figure 7: Separate pathways to add a layer of difficulty and strategy.

Table 8: Enjoyment Process Elements

Enjoyment Process Elements	Application in the game
Engagement	The game's narrative, music and sound, words and language, and graphics help grab the player's attention.
Challenge	Enemies get stronger for each level the player progresses and the employment of different towers may be necessary. Incorrectly answering the quiz prompts the character to give feedback but not in-game currency.
Flow	There are fewer enemies and enemy types at the beginning, allowing the player to get a feel of the game before increasing the difficulty by adding more enemies and types. For example, earlier patients may

	only be exposed to the danger of nicotine addiction (without the addition of the other 250 harmful chemicals) or second-hand smoke, which would be the lesser negative chemicals and which are easily solved by behavioral treatments or by avoiding the wrong environments. The next enemy types would be cigarette sticks, tobacco leaves, and the other harmful chemicals that may cause cancer for tobacco smokers.
Persistence	Failing a stage when the body part or organ reaches 0 health allows the player to retry the same level. Answering quizzes correctly in a row gives more currency to reward consistent attention to information and detail.
Mastery	The player's score in the quizzes will be shown and compared to the maximum possible score. Other statistics such as number of enemies defeated, least number of towers used, currency spent, currency saved and so on will be shown and given a high score so players may attempt to do better on their next attempt. The game may feature a harder difficulty that introduces various challenges to test the player's mastery of the game.

### 3.4.2 Enjoyment Process from CBGD Framework

The Likert scale will be used to measure the heuristics evaluation of the participants on the playability of the game, as well as what aspect of the game that impacted them the most. In order to quantify this, the heuristics evaluation for mGBL will be used, shown in Table 9. The four main components of the heuristics evaluation strategy will be measured, namely the GU, MO, GP, and LC.

Table 9: **Sample Questions regarding the game in the Questionnaire using the heuristics and the Likert Scale**

Question	Category
Did the audio-visual representation support the game?	Game Usability
Was the screen layout efficient and visually pleasing?	Game Usability
Can the game and play sessions be started quickly?	Mobility
Were interruptions handled reasonably?	Mobility
Are the players rewarded and are the rewards meaningful?	Game Play
Does the game story support the gameplay and is it meaningful?	Game Play
Can the content be learned easily?	Learning Content
Does the game provide learning content?	Learning Content

## 3.5 Game Development

The Unity game engine will be used to develop the game, similar to Drug Defense. The game assets will be made using Blender, a software designed to make 3D models. Once the narrative for the game has finished, an artist will be commissioned to help with the art for the journal

in-game. Specific details regarding the game will be found in the game design document.

The game's development will take place during August to December, 2021. The first things to be accomplished will be the starting menu and level selection scenes in Unity. Afterwards, all the necessary assets and models will need to be completed for implementation into the game. Finally, the actual creation of the game's levels and narrative will be done. Upon completion, the game will now be available for testing. The researchers are coordinating with a psychologist group to create a narrative for the game, as well as making the story as realistic as possible for the immersion of the player. The content of the questionnaires that will be administered before and after the game will also be worked on by both groups.

## 3.6 Testing

The testing of the game itself will be carried out in three phases. First, the participants will take a pre-test cognitive questionnaire before playing the game proper, for 10 minutes. Upon completion of the test, they will then play the game for a maximum of 40 minutes. Finally, the testers will then be given a post-test cognitive questionnaire, to be answered for 15 minutes. Questionnaire items from the Heuristics Evaluation Strategy for mGBL were followed up to participants after the completion of ethics clearance from the researchers' side.

There were two playtesting sessions conducted for this research, the main goals were to identify bugs for fixing and to gather data for gauging various aspects of the game. The first playtesting session was a pilot test to identify initial bugs and issues with the game, as well as accept initial feedback from testers. The second session was conducted from February 14 to March 2, 2022, with various synchronous sessions for 60 participants, each session lasting 1 hour and 30 minutes at most.

## 4 Results and Discussion

With assistance from the psychology group, the researchers have successfully gathered data from 60 participants. During the span of February 14 to March 2, 2022 the data for the tobacco knowledge pre-test and post-test were gathered. The post-test results given to participants for the game experience were gathered from March 3, 2022 to March 14, 2022.

### 4.1 Tobacco Knowledge Test Data

A total of 60 participants answered a pre-test cognitive questionnaire consisting of 20 different questions overall regarding various facts and information surrounding tobacco and nicotine in which the results are then recorded. Upon completion of the pre-test questionnaire, the participants then proceeded with testing the game. After playing through the game, a post-test cognitive questionnaire was then given for the participants to answer.

This questionnaire included the same 20 questions as the pre-test.

The highest scores attained during the pre-test and post-test was 20 out of 20. According to the pre-test results, 1.66% of participants were able to achieve this score. As for the post-test results, the percentage of participants who achieved the perfect score was 21.66%. This leads to an increase of 20% of participants with a score of 20.

Following the highest scores for the pre-test and post-test results, the lowest scores obtained for the tests are as follows. The pre-test had a lowest score 6 out of 20 or 30%. As for the post-test, the lowest score is 15 out of 20 or 75%. Between the pre-test and post-test results respectively, there is a 45% increase in the lowest scores.

Finally for the average of the scores between both tests. The pre-tests have an average 12.28 out of 20 or 61.4%. The post-tests on the other hand have an average of 15 out of 20 or 75%. This is an average score increase of 13.6%.

Based on the results so far, it appears that there is a significant difference in the knowledge scores of all participants from the pre-tests and post-tests respectively as seen in Table 10. The t-test has an effect size of  $d = 2.656922$  which indicates that the game has succeeded in achieving its goal of increasing the player's knowledge.

Table 10: Pre- and Post-test Data

	Pre-test		Post-test		t	sig
	Mean	Std. Deviation	Mean	Std. Deviation		
Toxscreen	12.2833	2.99203	18.4667	1.37121	-16.952	.00

## 4.2 Game Evaluation Data

60 participants answered the post-test questionnaire that adapted the Heuristics Evaluation Strategy for mGBL. The highest possible score for each component is 5, with the lowest score being 1. There are 10 components for Game Usability, 3 for Mobility, 10 for Game Play, and 4 for Learning Content. The average for each category are 3.95, 4.32, 4.05, and 4.67 respectively. When all the scores are averaged, the total score the game received for the heuristics evaluation is 4.14 out of 5.

### 4.2.1 Highest Scoring Heuristics Rating

The highest scores for each category will be listed from GU to LC. GU1 signifies the audio-visual representation that supports the game, which is scored at 4.34 out of 5. This would mean that the players appreciate the sound and visual effects found in the game. From the tower designs, sound effects upon turrets firing or when Dra. Tina responds to the player, to the health bars and change in texture which all contribute to the players' experience.

Journal entries also play a part in the enjoyment of the players.

MO1 describes the game and play sessions being able to be started quickly, with a score of 4.62 out of 5. Toxscreen succeeds in starting up quickly, when initially opened as an app, when the player selects a level, and when they play said level.

GP1 denotes that the game provides clear goals, with an average score of 4.67 out of 5. The game's goals are understood by the players. They know that the currency is used to spend money on towers and global spells to help defend the objective which is the lungs, and to gain more currency, they know they have to pay attention and answer the correct quiz questions. The narrative of the game also plays a hand in this, as the story aspect of the game helps the game realize its goals.

LC4 depicts how understandable the content is, with a score of 4.75 out of 5. Whether players get the correct answer or not, they have the ability to understand why a certain quiz answer is the correct one, and learn from it. Elements of the game such as the harmful effects of smoking, the gameplay, the story and quiz elements, the content, and the game itself is said to be understandable. LC4 also has the highest average in comparison to the other components.

### 4.2.2 Lowest Scoring Heuristics Rating

Following the highest ratings, the next four components are the lowest ratings in their category. GU6 has a score of 3.58 out of 5, which describes how the game controls are convenient and flexible. Players have mixed reviews regarding the flexibility and convenience of the game's controls. Some have said that there is ease of access to weapons, being the towers and global spells, and the currency, so the controls are easy to learn and use. However, another group stated that the controls are inconvenient, although not too bothersome.

MO3 speaks of game interruptions being handled reasonably, with a score of 4.08 out of 5. Interruptions, if they do happen, will be handled well by the game. If Toxscreen crashes, it will drop players back into the current level they were at. No feedback regarding the game crashing has been made, however a few have said that their phone's hardware affected their ability to process certain actions faster such as selling turrets, which influenced their game experience.

GP8 describes the game not having any repetitive or boring tasks, with a score of 3.25 out of 5. This component is the lowest scoring of all the components, which shows that, despite having an average score still higher than half, the players have found the cycle of tasks of listening to Dra. Tina, placing down turrets to defend the objective, and answering quizzes repetitive or boring, despite the newly introduced mechanics of global spells, unplaceable zones,

and branching paths. Few participants have also stated that the game does get repetitive after some levels.

Finally, LC1 shows that the content of the game can be learned easily, with a score of 4.48 out of 5. The players found the questions easy to learn from, contributing to the fact that Dra. Tina discusses facts related to smoking before giving quiz questions. This component has the highest average in terms of lowest component ratings per category.

#### 4.2.3 Heuristics Evaluation

From the given highest and lowest scores of each category, it is inferred that there is no issue with the Mobility and Learning Content categories. The scores for these two are mostly skewed towards 4 and 5, and each individual component's score is above 4. However, some Game Usability and Game Playability components have an average total score lower than 4, but still higher than 3. There are still areas for improvement regarding the game's interface, controls, and mechanics.

#### 4.2.4 Feedback

Players have given feedback on which parts of the game they liked the most. The three outstanding qualities of the game described to be liked the most were the visuals of the game, such as art and 3D models, journal entries and the story narrative aspect of the game, and the fact that the game is based on the tower defense genre. Attention has been given to the texture of the lungs changing once it is damaged enough, to the map design, and the user interface of the game. The educational aspect of the game and the quiz as a game mechanic for currency and a storytelling element were also praised by participants. Finally, some have said that the easy to learn controls, on top of the game being strategic with the tower upgrades, are their favorite part of the game.

On the other hand, players have also mentioned which parts of the game they liked the least. The most common feedback regarding the least liked aspect of the game has to do with the build time being too short, which could be resolved with the introduction of an alternative difficulty that gives players one whole minute to set up, instead of 15 seconds. One thing to note is that Toxscreen has an increased amount of build time from the initial 10 seconds. Some participants have said that it was easy to misclick certain elements of the game, such as tower placement and the quiz answers, although the researchers are unsure of how to resolve those, as the buttons of the quiz answers each take up 1/4th of the screen. The researchers could use double clicking or holding to resolve misclicks regarding tower placement, however there are also feedback against the inconvenience of having to double tap to upgrade and holding down the sell button to remove towers.

Because of the tower defense genre, a few have given feedback regarding a lack of white grid overlay for tower placement and the limited tower choice of the game. Some have also given feedback regarding the clarity of the game, in regards to the journal text being slightly difficult to read, enemy pathing being unclear, no audio cue for insufficient money, and the tower abilities and upgrades. The journal text will be edited for easier readability, and the enemy pathing issue will be resolved with a tutorial explanation and an initial colored object coming out from the spawn points down towards the objectives to visibly show where enemies would path, in the case of intertwining paths.

#### 4.2.5 General Feedback

Bug reports and general feedback from the participants were also taken into consideration. The researchers have worked on checking and resolving the given bug reports on top of updating the game based on resolvable least liked feedback. General feedback mostly covers messages of encouragement from participants and feedback covered from previous entries. Players have said that the game is overall very fun, and that they would play it regardless if it was for the research study or as an application that they found in the App Store or Google Play.

## 5 Conclusion

### 5.1 Effectivity of the Game in Increasing the Knowledge Regarding the Effects of Tobacco

From the results gathered from the tobacco knowledge test, the game was effective at increasing the knowledge of tobacco to users. There was an overall increase of test scores from participants who played the game compared to those who did not. Players were shown to be able to retain tobacco and nicotine knowledge shared by Dra. Tina during gameplay. The participants have also remarked how understandable the game's content is and how easy it is to learn.

### 5.2 Effectivity of the Game in Providing Entertainment and Fun

The results of the game evaluation data acquired from using the mGBL heuristics strategy showed positive results, with the game having scored 4.14 out of 5 shows that it is effective in pleasing the players. The open-ended question for general feedback that players answered at the end of the testing session also reflects this. The game was positively received by the participants, and they have stated that they found Toxscreen to be very enjoyable and fun. Some have even stated that they would be willing to play it if they found it by themselves on their smartphones and not as a research experiment.

### 5.3 Issues

Due to the circumstances caused by the COVID-19 pandemic, the testing shifted towards an online setting. This has caused issues with participants including difficulty of participant attendance, data gathering during sessions and actual participation. The pandemic has also caused problems in game development, as the researchers were limited in collaborating with coding and forced to upload, send, and download game files back and forth which was not feasible. Blackouts and typhoons affected the researchers' work and slowed down progress, because of the purely online setup. There was also a difficulty in finding a trusted 3D modeler online, which one of the researchers had to take charge of.

Due to time constraints for testings, the game's balancing and overall flow had to undergo adjusting. There was also difficulty with importing and using blender models in Unity which caused issues during development. From the testing, there were also several reports of issues or bugs reported by participants such as level design, small button and text sizes, and game difficulty to name a few, some of which have been resolved, but the researchers were not able to answer every least liked feedback due to the impractical nature of resolving every feedback.

#### 5.4 Recommendation

The researchers' major recommendations for the game is to continue the research by exploring other types of substance abuse, as this research was made to continue Drug Defense which originally planned to cover illicit drugs as well. One idea is to focus around illicit drugs such as marijuana. It is also recommended to create a brand new standalone game using the source code rather than add-on another major game to the current one as there might be conflicting mechanics and the research focused on the game may become too broad in scope.

The game would benefit from better balancing in terms of difficulty and improvement to overall game design. More map variations may help further increase fun and player engagement. Finally, an increase to both enemies and turrets may also increase strategy and overall enjoyment of the game.

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# Hot-air Penguin Pair

## A Breath-controlled Video Game to Lower Stress Levels of College Students

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### ABSTRACT

This study aimed to create a mobile Android breath-controlled video game to teach players the 4-2-4 breathing technique to reduce stress levels in players. The game was made with Unity and distributed to respondents who were required to play the game using their own microphone set-ups connected to their Android device. Users answered a pre-test survey before playing the game and a post-test survey after 5 days of playing at their own discretion. Both surveys contained the PSM-9 questionnaire while the latter contained additional questions for user feedback. Based on the results and analysis of data from 8 users who participated in the study, there was no significant difference in the user stress levels between the pre-test and post-test PSM-9. The respondents, however, generally found the game calming and relaxing. Additionally, there was a significant difference in the user-reported and game-reported accuracies of the game's breath detection. Future studies should improve upon game replay value through better game design choices like choice of music, splitting the game into levels, and including additional helpful UI elements. Future studies can also benefit from a larger sample size and improving the breath detection algorithm.

### CCS CONCEPTS

- Applied computing → Computers in other domains → Personal computers and PC applications → Computer games
- Human-centered computing

### KEYWORDS

Breathing techniques, Mobile Video Games, Breath Detection, Breathing Video Games, Stress Reduction

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## 1 Introduction

### 1.1 Context of the Study

Stress is a common human experience that is often used in everyday conversation to refer to psychological stress, which is the case in this study as well. Stress or psychological stress, as far as this study was concerned, was defined as a taxing or exhausting feeling caused by stressor(s) experienced by the person that goes beyond the person's ability to cope. It is a natural and unavoidable reaction that is not much reason for concern in small doses. This is not to dismiss the cases when more major acute stress has caused serious health problems, though this mostly happens in people with pre-existing conditions [1]. However, stress is more often associated with serious health risks when it is chronic or experienced over a prolonged period. Several studies have shown links between stress and negative impacts on the person's body, mood, and behavior [20].

Some studies about stress have highlighted the stress levels of college students. A study which investigated the association between a students' perceived levels of stress and the sentiment and emotions of their tweets found that most of the participants reported average or high levels of stress [17]. Another study by Bernal et al. [6] done in a Philippine university showed that the "level of academic performance of students is at average level with a high level of stress."

In more recent times, the onset of the COVID-19 pandemic had only exacerbated stress levels among people, including students. Tee et al. [32] conducted a survey that garnered 1879 respondents in the Philippines during the first month that COVID-19 was declared a pandemic in the country and found that 26.4% reported mild stress signals while 13.4% reported moderate to severe stress signals. Additionally, they found that "students reported greater psychological impact as well as more depressive, anxiety and stress symptoms compared to those who are employed." A similar study by Wang et al. [34] conducted in China that garnered 1210 respondents found that 24.1% were considered to suffer from mild stress, 5.5% were considered to suffer from moderate stress, and 2.6% were considered to suffer from severe and extremely severe stress. They also found that students were "associated with a greater

psychological impact of the outbreak and higher levels of stress, anxiety, and depression.” Salari et al. [28] offered a more general overview of stress levels. They performed a meta-analysis of several studies gathered from multiple databases and found that “the prevalence of stress in 5 studies with a total sample size of 9074 is obtained as 29.6%.” These findings showed that among other groups, students faced increased stress levels with the rise of the pandemic. With or without the pandemic or any major global crises, it is important to find ways to reduce stress levels to manageable levels.

Some ways that have been studied and shown to reduce stress levels include exercising [4], music therapy [13], gratitude journaling [12], yoga, meditation, and humor [9]. Proper breathing, in particular, was one method that had been repeatedly studied and observed as a way of reducing stress levels. Perciavalle et al. [24] reported a possibility that their deep breathing technique improves self-reported mood and stress. Similarly, Ma et al. [18] found that their experimental group that was subjected to breathing interventions had significantly decreased negative affect, cortisol levels, and increased sustained attention. In Rygiel’s study [27], the need for different types of relaxation techniques to mitigate negative effects of stress was highlighted and emphasis was placed on a “portable intervention.” Rygiel also recommended promoting the use of the deep diaphragmatic breathing technique in lieu of classical meditation programs which are usually “long or expensive, and, thus, inconvenient or unavailable for a majority of students.”

There was also a growing number of studies that focused on using the user’s breathing as input for the video game through creative means such as with the use of a specialized gas mask [33] and a combination of a computer and mobile phone [15]. Other studies proved that with the help of biofeedback video games, they were able to teach breathing and relaxation skills to children with Attention-Deficit/Hyperactivity Disorder (AD/HD) [3] and improve pulmonary function in stroke patients [14].

However, most of these studies made use of highly specialized equipment that aren’t easily available to people, except perhaps for the studies done by Zafar et al. [35] and Shih et al. [29] which rely on smartphones, and none centered on reducing stress levels specifically. As such, the interest of the researchers for this study was in designing a mobile video game and incorporating breathing techniques to train players in better breathing practices that reduce stress levels.

## 1.2 Research Objectives

With the evidence showing that college students have faced increased stress levels since the onset of the pandemic, the researchers aimed to create a game controlled using the player’s breath. The intention was to introduce the practice of a proper breathing technique through the game mechanics and see if there was any effect in the players’ stress levels before

and after playing the game. Specifically, this research had the following goals:

1. To determine how a mobile game can be designed centered on a particular breathing technique with the intention of lowering players’ stress levels,
2. To determine how breathing patterns of players can be captured through an external microphone,
3. To measure changes in users’ stress levels before and after playing the game,
4. To determine how users perceived the accuracy of the game’s breath-detection, and
5. To gather user feedback and evaluation of the use of the application.

## 1.3 Research Questions

In fulfilling the objectives of this study, the researchers sought to answer this question: How can a game for mobile devices that relies on players’ breath as input be designed to effectively reduce players’ stress levels? Particularly, this research sought to answer the following sub-questions:

1. How can a mobile game be designed around a breathing technique to lower players’ stress levels?
2. How can breathing patterns of players be captured through a headset’s microphone?
3. How effective was the mobile game in reducing the stress levels of players?
4. How accurate was the breath detection of the game from the players’ perspective?
5. What were the users’ feedback and evaluation of the application?

## 1.4 Scope and Limitations

This study targeted undergraduate college students of the Ateneo de Manila University as they were the most easily accessible to the researchers. Ideally, measuring stress levels would go hand in hand with measuring physiological factors such as heart rate and blood pressure as was usually done in other studies. However, as it was unsafe to be in physical contact with people at the time of conducting this research, those factors fell beyond the scope of this study. This also implied that due to the online nature of this study, extraneous factors arising from the environment in which the participant chose to undergo the study was beyond the control of the researchers. This study also sought to examine the effectiveness of reducing their stress levels as defined in Chapter 1. Additionally, this study was also limited to people who do not have any respiratory conditions and who were staying in the Philippines at the time of participation in the study. It also did not consider how the game’s genre contributed to the stress-reduction aspect of the game, and it did not investigate how the length of time in playing the game affects players’ stress levels.

The researchers have decided to create a game on a mobile device because connecting a headset to a laptop or similar device may make the sound input detection originate from the laptop instead of the headset's microphone, leading to inaccuracies in playing the game.

### 1.5 Significance of the Study

This study sought to benefit people experiencing stress beyond normal levels by providing them with an alternative method to reduce their stress levels, one that can be self-taught with little to no guidance from other people. The online nature of the game meant that it should be more readily accessible to those with the proper devices and a stable internet connection. Additionally, this study could also help future game developers and therapists by providing input on how best to design a mobile video game that incorporates breathing techniques.

## 2 Review of Related Literature

### 2.1 Stress

Stress as a response to stressors can involve physiological effects such as palpitations, sweating, shortness of breath, and fidgeting; psychological effects can include the augmentation or increase of already existing negative emotions [2]. Long term exposure to stress can lead to heart disease, depression, migraine headaches [21], loss of sleep and appetite, muscle tremors [23], and anxiety disorders [11]

Because of the effects of exposure to stress, there were many efforts to reduce stress. Tai Chi [10], yoga, distraction, humor [9], mindfulness [20], relaxation and distraction [7], music [13], exercise [4], and gratitude journaling [12] were just some of the many methods that had been used in studies regarding stress reduction. The use of breathing therapy [22], [8], [5] and casual video games [25], [30] were also shown to reduce stress.

### 2.2 Breathing Therapy and Resonance Frequency Breathing

There is a large body of literature linking proper breathing techniques to numerous health benefits. According to Courtney [8], in a normal state, the lungs and all the related muscles necessary in breathing move in coordinated actions created by the diaphragm, scalenes, intercostals, abdominals and accessory muscles of respiration. This coordinated muscle can be disrupted or lost due to diseases or as a response to psychological stress. However, "controlled respiration can help the system return to a physiological rest state," which was in line with one of the main goals of breathing therapy, namely to "provide a means for regulation of mental and emotional states." Similarly, a study done by Brown et al. [5] elaborated further on yoga or yogic breathing and discussed the benefits and risks of certain breathing techniques used in other studies. "Yoga practices are associated with reduced levels of stress markers,"

according to Brown et al. Yoga breathing theoretically stimulates an underactive parasympathetic nervous system (PNS) which in turn "affect key anatomic structures and neural pathways" that inhibit stress markers in the body.

In addition to simply controlling or slowing down one's breath, another study [31] stressed the importance of breathing at Resonance Frequency (RF). Steffen et al. investigated the role of RF in improving heart rate variability biofeedback (HRVB) training. In HRVB, it is important to identify a person's RF and teach them to breathe at this rate. In their study they mentioned that each person had their own RF that can be identified. While the range is typically from 4.5 to 7.0 breaths per minute, usually 6.0 breaths per minute is when the breathing and the heart rate become synchronized or resonance. The benefits of breathing at RF, according to their study, was that heart rate variability (HRV) increased the more the person slowed their breath to the point of RF. Increased HRV, in turn, was linked to improvements in health, mood, and adaptation to stress.

### 2.3 Breathing Techniques

For this study, the researchers aimed to design the mobile game around helping players control their breaths to 6.0 breaths per minute, or the typical RF in humans. To achieve this, the researchers decided to adopt a 4-2-4 paced diaphragmatic cycle as done in Russell et al.'s [26] study. This breathing technique made use of four seconds of inhaling followed by two seconds of exhaling and ending with a four second pause before repeating the cycle. While there exists a number of other breathing techniques that have been proven to improve a person's well-being, they were found to be unsuitable for the study either because they were difficult to simulate in a mobile game or they were difficult to implement following the human RF.

Courtney's [8] investigation on breathing and breathing therapy mentioned a few possible breathing techniques. The first breathing technique is called the Buteyko Breathing Technique (BBT). This technique is primarily used to correct acute and chronic hypoxemia and has also been shown to reduce medication use with no deterioration to the lung function and asthma control in asthma patients. Another breathing technique mentioned was the Intermittent Hypoxic Training (IHT). This technique involves deliberately creating controlled levels of hypoxia or oxygen deficiency at set intervals with rest periods. IHT had been found to enhance antioxidant capacity and improve metabolism and mitochondrial function. This was mainly practiced by athletes to simulate practicing in conditions with low oxygen, which was normally found in higher altitudes, but it had also been studied and used for treatment of diseases. The BBT and IHT methods were unsuitable for this study since BBT involved holding one's breath for as long as possible before normally breathing, meaning that it did not pay attention to human RF, while IHT, on the other hand, did not necessarily focus on

controlling one's breath as it did on conditioning athletes to train with limited access to oxygen. In addition, IHT is normally done with the aid of a special mask that controls oxygen levels.

Naik et al. [22] performed a study using a modified anuloma villoma pranayama or alternate nostril breathing technique. Instead of the traditional version that involved inhalation, hold, and exhalation at a ratio of 1:4:2, this study modified the ratio to 1:1:1. It was mentioned that the traditional method was not suitable for beginners and an increased duration of holding one's breath can have adverse effects on the body. Meanwhile, the modified breathing technique adopted for this study resulted in a significant reduction in heart rate, systolic blood pressure and diastolic blood pressure following a 12-week practice of slow deep breathing exercise. Despite these benefits, alternate nostril breathing was difficult to use for this scenario as well since a full cycle worked differently considering that the participant would have needed to take turns inhaling and exhaling with the left and right nostrils.

In Brown et al.'s [5] study, the different kinds of breathing discussed include but are not limited to paced breathing, coherent or resonance breathing, resistance breathing, unilateral breathing, moving the breath, and breathing with movement. Breathing rapidly could have led to air trapping for patients with chronic obstructive pulmonary disease. Rapid or forceful breath was also associated with numerous risks involving triggering panic attacks, manic episodes, PTSD flashbacks, and was unsafe for pregnant patients and patients with medical complications including but not limited to cardiovascular disease, high blood pressure, and lung disease. Since rapid breathing posed medical risks, the researchers decided to forego this technique as well. Breathing that involved movements or imagination as well could not be adopted as these were difficult to measure and ascertain with just a mobile device and microphone. Unilateral breathing was the same as alternate nostril breathing, which had already been ruled out in a previous explanation. Resistance breathing, or the partial obstruction to airflow through means such as pursed lips, was also tricky to implement since this meant that the microphone must be positioned in front of the mouth to detect exhalations coming from the mouth. In effect, this will make it harder to detect inhalations through the nostril. This left paced breathing and coherent breathing as the remaining breathing techniques that can be feasibly simulated in the study. Russell et al.'s 4-2-4 breathing technique, conveniently fell under the paced breathing group of breathing techniques.

Thus, among other techniques, the 4-2-4 paced diaphragmatic cycle fulfilled the needs of our study. This was accomplished while sitting down and the pattern, according to Russell et al., maximized the effects of respiration on high frequency-heart rate variability. In addition, the results of their study showed that participants found this technique easier to follow and more relaxing than the 5-5 breathing pace which excluded a post-exhalation phase.

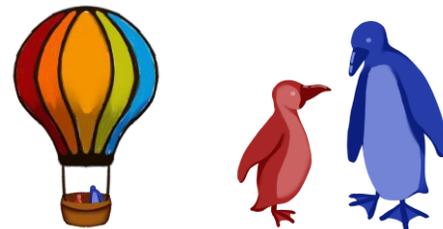
## 2.4 Breathing Games and Biofeedback

There were several existing studies that investigated using players' breathing as input to a video game and including biofeedback. Tennent et al. [33] looked into the viability of using the player's breath in five different games where breathing took on different roles: as the only control, secondary control, and ambient control. The breathing was measured through a specialized gas mask that players had to wear in order to play the games. They concluded that "breathing is a viable, interesting and fun control method for gaming" though it could not serve as a direct replacement for any other control type. Another study [15], proposed a new breath interface framework to control certain actions of players within a game with the use of a computer to display the game, a smartphone that calculated the angle that it was being held at, and the users' breath. However, while both studies made use of biofeedback to inform players about their performance in the game, they did not focus on deliberately designing a game that uses biofeedback to train players towards some end such as learning proper breathing techniques. In addition, the first study made use of a modified gas mask which was not easily obtainable while the latter used computers and smartphones which, while more widely available, were not as mobile and convenient as designing a mobile game, i.e., a game that would require a smartphone only.

## 3 Methodology

### 3.1 Game Development and Design

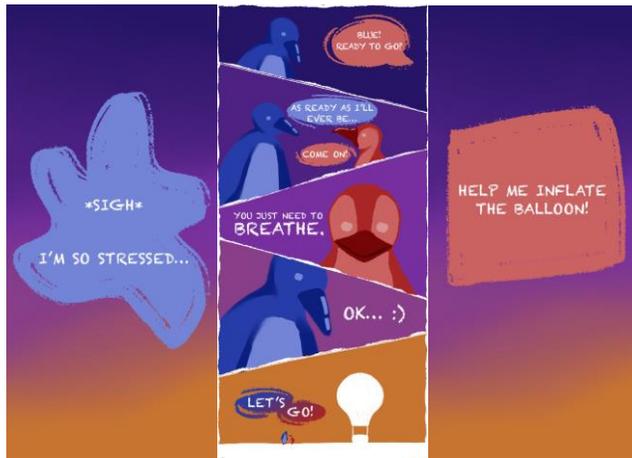
The game that was developed by the researchers is entitled "Hot-air Penguin Pair" (HPP). This game was developed in Unity by the researchers according to their prepared Game Design Document (GDD). All visual assets were also created by the researchers. Sounds and music incorporated in the game was sourced online. The game was made available to respondents via a link wherein they downloaded the game and installed it directly to their Android mobile device.



**Figure 1: Hot-air Balloon and Penguins Assets**

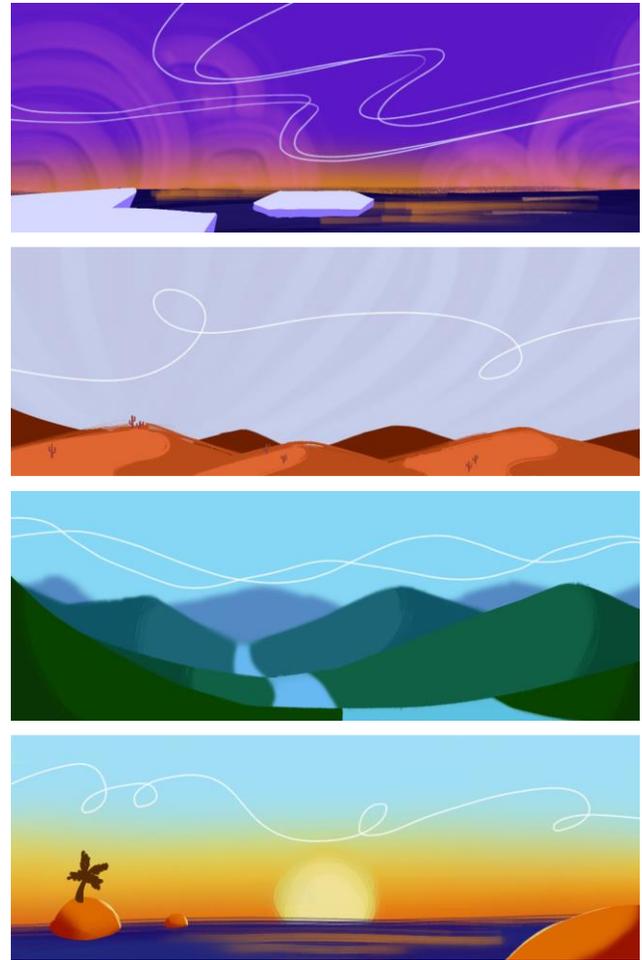
Figure 1 shows the assets used that represent the main characters of the story. The Hot-air balloon represents the avatar for the player as this will be shown on screen while the player progresses. Riding the balloon are the two sole

characters of the video game: Red and Blue. Red is the shorter and red penguin who invites Blue on an adventure in a hot-air balloon. On the other hand, Blue is the taller and blue penguin who appears visibly stressed in the beginning cutscenes of the game and represents who the player must assist to overcome Blue's difficulty through their maintained proper breathing technique.



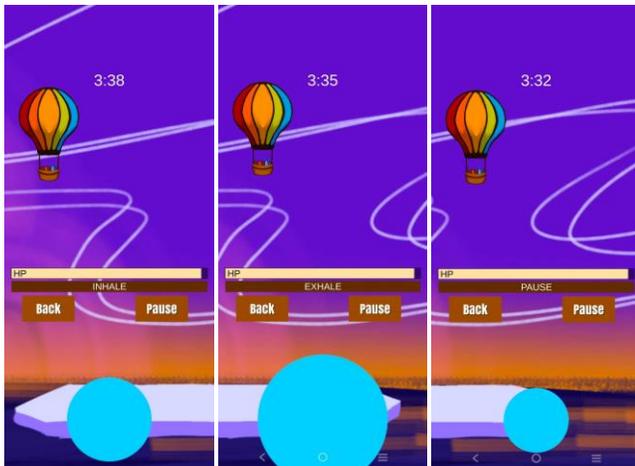
**Figure 2: Tutorial Cutscenes**

At the beginning of the Tutorial section of the game, players will find a short series of images that serves as a cutscene giving a short background of the story behind the game. The cutscenes show Blue who is stressed and Red inviting Blue to go on an adventure on a Hot-air balloon. At the end, Red asks Blue to help inflate the balloon, which the players are also invited to do through proper breathing technique in the next screen. Some of the assets used in the cutscene are illustrated in Figure 2.



**Figure 3: Location Assets**

The core gameplay in HPP was surviving through four different locations, as seen in Figure 3, by following the 4-2-4 diaphragmatic breathing cycle [26]. The four locations are illustrated and named, in order, as Antarctic Region, Desert Wasteland, Verdant Valleys, and Penguin Paradise.



**Figure 4: Main Game Screens**

Figure 4 are screenshots of what the game looks like during the Main Game section. From top to bottom, the components of the screen are the following: a timer to indicate how much time is left (players must survive a total of 1 minute for Tutorial mode and 4 minutes for Main Game Mode), the hot-air balloon representing the player avatar, the hit points (HP) bar, a text indicating the current breathing phase (inhale, exhale, or pause), the back and pause buttons, and the visual breathing guide.

If the players' breathing pattern follow the 4-2-4 cycle, shown on-screen via a visual guide, then the hot-air balloon will retain its HP, if it is still at full HP, or gain hit points and stay afloat. Otherwise, the balloon will lose HP and descend. In addition, the background images are programmed to slowly move to the left which, from the players' perspective, makes the hot-air balloon appear to be advancing through the various locations.



**Figure 5: Ending Screens**

The game ends when the players get through all four locations or if the balloon loses all its HP before getting through the fourth and last location. Depending on where the players are located at the moment the game ends, players can see different endings which are shown in Figure 5. These are

accompanied by in-game text describing the situation that Blue and Red face in the locations they ended up in.

### 3.2 Data Acquisition and Analysis

Data was collected from school year 2021-2022 undergraduate college students of Ateneo de Manila University. Approval from the university's ethics committee was obtained prior to conducting this study.

The researchers used a snowball sampling technique in which they contacted potential participants that fit the criteria of the study, invited them to take part, and asked the participants to recommend other potential participants or extend the invitation as well. The researchers primarily reached out and sought for respondents through online social media.

Interested participants clicked on a provided link found in the social media ads that takes them to a Registration Form. This form contained the details of the user study; explained what the participants could expect, the benefits and risks of the study, confidentiality protocols; and provided the investigators' contact information. From here, interested participants answered the Registration Form questions which were reviewed by the researchers for participant screening. Within the next 3 days, those who did not fit the inclusion criteria were emailed later saying that they cannot proceed with the next steps of the user study. Those who did fit the inclusion criteria received an email that contained instructions for the next steps. Particularly, this email contained a link to another Google Form called the Consent and Scheduling Form and also contained their assigned user code that was predetermined by the researchers. The user code was associated with the email address that was provided in the Registration Form.

The Consent and Scheduling form contained once again the details of the user study and formally asked participants to provide their informed consent to participate. In addition, one section contained a link to Calendly.com, an online scheduling platform which required users to indicate their name and email in picking out the schedule for a session with the researchers. The form indicated that participants should use their user code and obf email in scheduling. All the information given were still treated with strict confidentiality. Once the participants had scheduled a meeting and filled out the form, participants submitted the form and awaited further updates from the researchers. They received the link to join the online session an hour before their schedule.

At the beginning of the online session during the time that the participant scheduled, the participants were greeted and also briefed on the procedures for the session. If the participants had no questions, they were first given a link to a pre-game questionnaire that contained the Psychological Stress Measure (PSM-9). Once they were finished answering the form, they were then given access to download the game with the investigators being present to provide assistance

when necessary. The participants then spent the remainder of the meeting session completing the tutorial section of the game. Five minutes prior to the end of the session, whether the participants had completed the tutorial section or not, they were informed about the next steps in the user study. Specifically, they were told that they will be emailed by Calendly a follow-up questionnaire after 5 days containing another PSM-9 and feedback questions. Within those 5 days, they were given a recommendation to use the app after they wake up in the morning and before they go to bed, but they may use it more often if they wish to. In addition to the above, the game was programmed such that it automatically sent logs of the participants' game performance while the app was being used. For this, Firebase was integrated into the game to track user performance. In particular, the data being collected were: 1) the number of times and duration the app was launched, 2) accuracy of players' game performance measured by total HP loss over the number of checks the game performs, and 3) the total duration of each playthrough, 4) the game mode that player used (i.e., Tutorial or Main Game modes), and 5) the user code associated with the logs. This was part of answering the research questions.

Data were not collected from participants who did not fulfill the inclusion criteria or gave their full consent. In addition, data from participants who withdrew from the study were deleted.

### 3.3 Preprocessing and Calibration

Since audio values captured through the program ranges from -1 to 1, the values were squared to make all the values positive. The captured sounds were then grouped into intervals of 128 samples and within each group, the highest value was used to determine what breathing phase the player was in.

In order to measure the users' various breathing phases more accurately, the game also included an option to allow users to calibrate their settings. This feature can be found in the options screen and a screenshot is shown in Figure 6. The calibration gathered three data: the volume of users when inhaling, the volume of users when exhaling, and the environmental volume or the volume of users when they're neither inhaling nor exhaling. Using these data, the game adjusted its sound-recording algorithm to capture player's breath and reflect it in the game more accurately.



Figure 6: Calibration Screen

### 3.4 Player Breathing Performance Accuracy

While the participants played the game, their breathing performances were automatically calculated in both the Tutorial and Main Game sections. Player performance accuracy was calculated with the following formula:

$$Accuracy = 100 - \left( \frac{totalHPLoss}{totalPerformanceChecks} 100 \right)$$

where totalHPLoss was the amount of in-game HP lost by the player when breathing incorrectly and totalPerformanceChecks was the number of checks that the game performs at intervals. For the game, the researchers decided to perform checks at every 0.5 seconds and use Unity's built-in Time.deltaTime attribute to determine the number of seconds that passed in between frames while playing. A small threshold was also included that increased the margin of error for players so that players weren't immediately penalized and marked inaccurate.

### 3.5 Research Questionnaires

Both the pre-game and post-game research questionnaires contained a section for the nine-item Psychological Stress Measure (PSM-9). The PSM-9 was "aimed directly at the state of feeling stressed, is suited for assessing stress clinically in the general population and serving as an outcome measure" [16]. It was simple, easy to administer, and reflects affective, cognitive, behavioral, and somatic components. The tool asked users to indicate on a scale of one to eight the degree to which the statements applied to them in the last four to five days.

Unlike the pre-game questionnaire, the post-game questionnaire contained an additional section for users to rate,

evaluate and provide feedback on HPP. This section sought to gather insight on the players' experiences as well as identify areas for further improvement.

## 4 Results

Out of the 13 people who registered for the user study, 2 did not fulfill the inclusion criteria. Eleven participants scheduled an online session, but only 9 participants were able to attend. One of the participants who attended the session did not proceed to the testing phase due to technical difficulties. All the respondents that pushed through with the testing phase of the study were college students from Ateneo de Manila University aged 21 to 23 years old. None of them reported having any respiratory conditions and all were residing in the Philippines at the time of the study.

### 4.1 Psychological Stress Measure Questionnaires

The PSM-9 was used in the pre-test and the post-test questionnaires to gauge the difference of the participants' stress levels before playing the game and after five days of playing the game at their own discretion. Table 1 below presents the results of the questionnaires.

**Table 1: Pre-test and Post-test PSM-9 Results**

Pre-test Averages	Post-test Averages	Pre-test and Post-test Differences
-1.92	-0.79	-1.14
0.71	0.96	-0.25
-0.11	0.11	-0.21
1.11	0.61	0.50
1.39	-1.18	2.57
1.79	1.43	0.36
1.18	1.68	-0.50
3.25	2.00	1.25

The pre-game averages and post-game averages were then analyzed using a paired t-test as seen in Table 2 below. The null hypothesis was that there was no significant difference between the results of the pre-game and post-game questionnaires.

**Table 2: Paired T-test Calculations for PSM-9 Results**

	Pre-test	Post-test
Mean	0.924107	0.602679
Variance	2.245057	1.324139
Observations	8	8
Pearson Correlation	0.646027	
Hypothesized Mean Difference	0	
df	7	
t Stat	0.784944	
P(T<=t) one-tail	0.229112	
t Critical one-tail	1.894579	
P(T<=t) two-tail	0.458224	
t Critical two-tail	2.364624	

Since the p-value = 0.458224 was greater than  $\alpha = 0.05$ , the null hypothesis was not rejected.

### 4.2 Player-reported and Game-reported Accuracy

Participants were asked in the post-test to rate the accuracy of breath detection using microphones on a scale of 1 to 5, with 1 corresponding to "highly inaccurate" and 5 corresponding to "highly accurate". The game also calculated the participants' breathing performance accuracy on a range of 1 to 100. To make the comparison of the two values on the same scale, the values from the game were divided by 20. These results can be seen in Table 3.

**Table 3: Reported Accuracy from the Game and Participants**

Player Report	Game Report
4	4.44
3	4.51
4	4.53
5	4.35
2	4.55
2	4.57
3	4.59
3	4.64

The player-reported accuracy and game-reported accuracy were then compared using a t-test. The null hypothesis was that there is no significant difference between the player-reported accuracy and the game-reported accuracy.

**Table 4: T-test Calculations for Reported Accuracy**

	Player Report	Game Report
Mean	3.25	4.524071
Variance	1.071429	0.00833
Observations	8	8
Hypothesized Mean Difference	0	
df	7	
t Stat	-3.46797	
P(T<=t) one-tail	0.005217	
t Critical one-tail	1.894579	
P(T<=t) two-tail	0.010434	
t Critical two-tail	2.364624	

Since the p-value = 0.010434 was less than  $\alpha = 0.05$ , the null hypothesis was rejected.

### 4.3 Participant Feedback Questionnaire

#### 4.3.1 Game Aspects

The user feedback survey showed that users encountered difficulties with the player HP display. On the question of “What was the most frustrating moment or aspect of the game?” Two users reported that their HP was going down despite them giving their best effort at following the breathing pattern showed on screen and they could not discern why. One user wrote:

“I am unsure why my HP was going down despite me trying my best to follow the rhythm of the inhales and exhales. I was unsure if I was breathing improperly or if my mic was picking up on something else.”

Three other responses highlighted issues experienced with game design choices. Particularly, one felt that the added layer of logging in to the game made them reluctant to play, one felt that the game was too long, and another user noted that in the Main Game section, when multiple backgrounds and music were incorporated, the change of the beat of music disrupted them from following the breathing pattern. Meanwhile, one other user felt frustrated from being unsure if their microphones were calibrated correctly.

On the question of “What was your favorite aspect of the game?” users generally found the graphics and art of the game pleasing to look at and described the game as “calming” and “chill.” To quote one user, “The art was very cute, and I like the little writeups about Red and Blue.” In addition, two users also noted that the in-game timer and breathing guide were helpful and two other users said that they enjoyed the breathing mechanics that were incorporated in the game.

#### 4.3.2 User-suggested Changes

For the questions “Was there anything you wanted to do that you couldn't?” and “If you could change, add, or remove anything from the experience, what would it be?”, one user wrote “I kind of wanted another circle to show my breathing too” as a means of comparing against how they are supposed to be breathing. Another user similarly suggested that they would

include an indicator in the game to show whether the users' breathing was being detected or not. They added, “It would be nice to see if the game is detecting your inhales and exhales properly so you know you're doing it right.”

In terms of game design, suggested changes include the following: changing the transitions between scenes in the Main Game section to make them less abrupt, implementing levels in the game to show progression more clearly, and carefully selecting other music so that they better match the intended breathing pattern.

#### 4.3.3 Microphone Settings

All users reported that they used wired earphones with attached microphones connected to their Android phones, however one user switched between Bluetooth earphones and wired earphones throughout their testing period.

With the question “Did you experience any difficulties in using the headphones?” users were asked to give a short answer response while giving a rating from 1 to 5 with 1 being “highly inaccurate” and 5 being “highly accurate”. two users answered that they were unsure about how well their breathing was being detected with one of them describing their earphones as “not very good.” The scores they gave were 4 and 3 respectively. One user did not mention difficulties with using their earphones but instead remarked on the difficulty with dealing with the background noise of their room in their home. This user gave a rating of 3. Another user who gave a rating of 3 in this question conveyed their concern about being unsure if they should breathe through their nose and mouth. They indicated in their response as well that “I would switch between the two especially if I got tired of one or the other.”

The remaining users that said that they experienced no issues with their headphone or that the breathing detection was accurate. However, the ratings varied with one giving 5, another giving 4, and the remaining two giving a rating of 2.

#### 4.3.4 Breathing Mechanic

On the question “How did the game's breathing mechanics make you feel?” two users brought up that they got tired of breathing at some point, especially during the inhalation phase of the breathing cycle, which was set to four seconds. To put it in one of their words, “The inhaling part was too long but I was already tired from inhaling.” Two other users said that they experienced difficulty and unfamiliarity when they first started out, but that they adjusted after some time. One of them stated “I think I felt relatively calm after I got more used to the breathing.” Three users, on the other hand, expressed that their mood improved with one of them stating that the game “felt like a meditation game” while the other two felt calmer due to the breathing pattern.

For the question “What are your main takeaways from the game, if any?” there was a general theme of learning the importance of proper breathing in the users' responses. Some mentioned how the game made them realize how poor their

own regular breathing patterns were while another brought up their awareness of their lack of focus recently.

“It’s hard to be focused these days, and it takes time and effort to actually sit down and ground yourself in reality. Games like this [sic] can help accomplish that, because I think it’s really important to sit with yourself for at least a few minutes a day.”

There was one, user, however that expressed doubt as to whether the game achieved its goal of teaching proper breathing techniques to users.

#### 4.3.5 Frequency of Playing

On the question of “How often did you play the game in the last five days?” 5 users said that they played “every other day” while three responded with “barely.” Most users stated their reason for playing at that frequency was because they had no time or that they forgot about the game. One user, however, got sick so they were unable to play for a period of time while another user answered that they were too impatient for the game.

## 5 Conclusion

The goal of this study was to contribute to the existing knowledge on stress reduction by exploring other means of decreasing people’s stress levels. To achieve this, the researchers thought to teach people how to practice proper breathing techniques through playing a video game. Thus, the researchers created a breath-controlled mobile video game centered on reducing the stress levels of players by teaching the 4-2-4 breathing technique. In doing so, the researchers sought to find out how games for mobile devices that relies on players’ breath as input can be designed to effectively achieve the objective of lowering players’ stress levels. Specifically, this study aimed to answer the following questions: (1) How can a mobile game be designed around a breathing technique to lower players’ stress levels? (2) How can breathing patterns of players be captured through a headset’s microphone? (3) How effective is the mobile game in reducing the stress levels of players? (4) How accurate was the breath detection of the game from the players’ perspective? (5) What are the user’s feedback and evaluation of the application? The findings from the user study are discussed below.

### 5.1 Designing Mobile Games for Teaching Breathing Techniques

From the feedback gathered in the post-game research questionnaire, many users appreciated the appealing visuals and graphical elements employed in the game. These were particularly helpful in this context as it lent to one of the goals of creating the game, i.e., on stress reduction. The game produced a calming effect at least based on some responses and helpful UI elements like the game’s breathing guide and timer were also noteworthy.

In contrast, several areas for improvement stood out from among the users’ responses. First, when designing a game that relies specifically on maintaining a breathing pattern, greater attention must be given to the choice of music incorporated. Several users noted that they preferred to have music that matched the breathing pattern of the game. In relation, better transitions also help especially in moments when players move to another area that has a different music.

Second, users expressed frustration on certain UI elements that they felt were missing or were not present enough in the game. While users showed that they were aware of the presence and purpose of the in-game HP bar, they could not immediately understand why their HP would go down in certain instances, especially those moments when they felt that they were following the breathing guide correctly. To remedy this, and to echo some of the suggestions from the users, other UI elements that explicitly indicate breath input detection must be included alongside the HP display.

Third, other minor game design choices can also be taken into consideration to increase replay value and consequently the frequency of playing the game. One user remarked that the game felt too long, so a shorter playthrough may be implemented or the game can be designed such that users are given choices among several durations. Another thing to consider was the log-in page, which served as a hindrance for players who wanted to quickly play the game. This was unfortunately unavoidable for this study as the log-in process was necessary to track user data in a remote testing setup. Lastly, some users also felt that the game would benefit if it was implemented such that it was split into levels. Story-wise, this matches with the idea of the penguins going on a journey from one area to another, but it could also give a better feeling of progression in the game. This perhaps can also be connected to how some users stated that they struggled with keeping up with the breathing mechanics at first but later adjusted. A breath-detection mobile game segmented into levels with varying difficulties signified by different breathing duration goals per level can perhaps help players strengthen their breathing techniques more effectively as compared to a single, continuous, and long breathing challenge. The easier levels, or the levels with shorter breathing duration goals, can serve to train players in preparation for the harder and longer levels.

### 5.2 Breathing Detection and Accuracy

For this study, the researchers utilized the microphone’s ability to capture sounds and relied on the volume of the users’ breathing. The assumption was that the different breathing phases were audibly distinct enough for the microphone to identify users’ breathing states. This was executed with the implementation of an in-game calibration function that captured the volume of the users’ breathing phases. The microphone then needed to be situated near the nostrils of the players to ensure best detection. As a consequence of allowing users to participate with their own earphone and microphone

setup, there may have been differences in the quality of sound captured which led to varying results in performance and opinions of perceived accuracy of breath detection.

On average, all the users gave the breath detection a combined accuracy rating of 3.25 out of 5. In contrast, the accuracy captured by the breathing algorithm gave players an average of 4.51. The calculated p-value 0.010434 was less than the alpha value 0.05. With these values, the null hypothesis that there was no significant difference between the player-reported and game-reported accuracy was rejected. This implied that player reported accuracy and accuracy captured from the breathing devices did not match and that there needs to be further improvement to make sure that these align.

### 5.3 Stress level Reductions

One of the main goals of the study was to create a mobile game focused on reducing players' stress levels by teaching the 4-2-4 breathing technique which was reported to be relaxing. Based on user feedback, the game was described as calming, relaxing, chill, and meditative. As a result of playing the game, some users reported as well that their main takeaway was to breathe better or to have an awareness of how poor their current breathing behaviors were. However, this was not always the case. There were responses from the user feedback which stated that some users had difficulty at the beginning due to unfamiliarity with the breathing pattern being taught, though they later adjusted. Additionally, there were some who felt that they got tired after playing the game for a while. They noted especially that the inhalation phase of the breathing felt too long.

Apart from the user feedback, the PSM-9 results were also tallied and analyzed to determine the differences in stress levels of users before and after five days of playing the game. Since the p-value 0.458224 was greater than alpha value 0.05, the null hypothesis that there was no significant difference between the pre-test questionnaire and post-test questionnaire was not rejected. Thus, the game was ineffective at lowering stress levels of players as there were no noticeable changes. It must be noted, however, that the frequency at which the users had played the game within their given time period varied between "every other day" and "barely." Moreover, this finding directly contradicted some user feedback as mentioned above which stated that some players found the game relaxing. One possible explanation for this was that users felt relaxed or calm only at the moment of playing the game. Stress, on the other hand, can be due to multiple stressors beyond the scope of the study and persists over a long period of time.

### 5.4 Recommendations

Based on the results of the study, several areas for improvements can be made on the implementation of the game itself and on conducting the study. First, to improve the game, the user feedback must be taken into consideration in the

game's design. One notable remark from users was to select music and create transitions to other areas of the game that better suit the pace of the breathing pattern that needs to be followed. In a sense, the audio, together with the visual breathing guide, should also function as a breathing guide to players instead of just being background music. Furthermore, the game's overall replay value must be improved, especially if the goal of reducing players' stress levels is to be realized. This can be achieved through the implementation of the following: app notifications to address players who often get caught up in their days that they forget to play, multiple levels with varying durations so that players can acclimate to the new breathing pattern, and, if possible, removal of a log-in screen or any other unnecessary steps to access the game.

For future researchers wishing to replicate the study, one recommendation is to conduct the study over a longer period and with a larger sample size with less limitations to the criteria for a more cohesive understanding of the effects of the game to various populations. As a means of reaching to a wider audience as well, the game can also be ported to other platforms such as IOS devices with consideration still to the means of detecting players' breathing. One concern, however, is the trend that some phone models no longer have a dedicated audio jack for wired earphones to connect to. For this study, all participants have with them in advance and used wired earphones with a microphone attached, but other studies may seek to explore possibilities that go beyond these limitations. Lastly, improvements can be made to the breathing algorithm implemented that filters out other noises to improve accuracy of breath detection.

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# Reef Warden

## A Game About Reef Protection and Preservation

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### ABSTRACT

Tubbataha Reefs Natural Park is a World Heritage Site in the Sulu Sea. Unlike other reefs in the Philippines, it has been shielded from degradation through the efforts of the Tubbataha Reefs Natural Park Foundation. However, efforts such as these suffer from lack of consistent funding, mainly depending on tourism and other channels dependent on the goodwill of the public. To address such, this research aims to produce a video game that promotes awareness of reef conservation and its challenges by showcasing the work of the Tubbataha Reef Natural Park Rangers. Promoting awareness will bring public attention to these efforts, potentially increasing the funding they receive from the public. Participants of the study experienced the game, taking a questionnaire before and after the experience. This questionnaire tested their awareness and willingness to help pertaining to these reef conservation efforts. The results were analyzed through hypothesis testing, specifically t-test and linear regression. It was discovered that the game was effective at increasing awareness of reef conservation but not willingness to help. This implied that the game delivered the wrong impression of the difficulty of reef conservation efforts as well as the threats faced by such efforts. The researchers recommend further development of the game after the conclusion of the study to address this.

### CCS CONCEPTS

• Applied computing → Education → Interactive learning environments • Applied computing → Computers in other domains → Personal computers and PC applications → Computer Games • Computing methodologies → Computer graphics

### KEYWORDS

Coral Reefs, Reef Conservation, Strategy Games, Educational Games

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## 1 Introduction

### 1.1 Context of the Study

Located in the Sulu Sea under the jurisdiction of the local government unit of Cagayancillo, Palawan, Tubbataha Reefs Natural Park - listed as a World Heritage Site by UNESCO - spans an area of 96,828 hectares. This includes the North and South Atolls, and the Jessie Beazley Reef. Tubbataha is an atoll reef with very high densities of marine species and is recorded to have the highest densities of white-tip reef sharks. It is also an example of a pristine coral reef with 100-meter perpendicular walls, extensive lagoons, and two coral islands [25]. Tubbataha thus holds much importance for its contribution to biodiversity alone.

Both in the Philippines and around the world, however, coral reefs are suffering from degradation linked to drivers caused by human activity. Examples include overfishing and land-use change [28]. However, the largest threat to Tubbataha is climate change. Increasing water temperatures, ocean acidification, and other forms of stress lead corals to expel zooxanthellae, resulting in a white and deteriorated appearance. The process is known as bleaching. Multiple major bleaching events have occurred in the Philippines between 1998 and 2010, with 95% of the corals affected in the latter year. Its principal cause was an El Niño, which resulted in an increase of temperatures in the Indian Ocean and waters in Southeast Asia. Tubbataha itself experienced an 18% decline in coral cover during 1998, and compared to 2010, it was only 1% compared to other Philippine reefs. Because of the reef's protected status and the decline in pollution and fishing attributed to it, the corals in Tubbataha recovered more easily from the bleaching events [24].

As a UNESCO World Heritage Site, Tubbataha is internationally recognized for its natural significance [23]. Furthermore, Tubbataha, like other coral reefs in the country, plays an important role in food security. Fishery production is supported

directly, while services that indirectly aid in food security such as tourism are facilitated [3].

To that end, numerous government and non-government organizations have undertaken efforts to conserve these reefs. These include the establishment of Marine Protected Areas (MPA) and legislation of laws and regulations explicitly for the defense of reefs. Of particular importance is the Tubbataha Reefs Natural Parks Foundation, responsible for the conservation of Tubbataha Reef. It sends Park Rangers to, inter alia, prevent illegal fishing, clear marine debris, and facilitate tourism efforts [24].

However, many of the organizations that are mandated to enforce these are chronically understaffed and underfunded [2]. The Foundation funds its conservation efforts primarily through tourism. This income is not consistent throughout the year since tourism may only be permitted during certain months due to weather conditions. Furthermore, only up to twelve rangers are on site at any given time to supervise a large area of over ninety thousand hectares.

Increasing public awareness about these efforts is one of the many ways to assist these organizations. Aside from tourism, there exist channels for the public to contribute through, such as volunteerism and donations [22]. The researchers believe that one of the more effective ways to extend awareness beyond acknowledgment of the issue is through the provision of an experience that is both accessible and impactful.

## 1.2 Research Objectives

This research will produce a video game that promotes awareness of marine conservation, specifically reef conservation and the challenges associated with it. The game aims to inspire others, especially the youth, to support marine conservation by sharing the work experience of the Tubbataha Rangers with its players. Although not the focus of the game, players will also learn about other necessary work done by the organization, such as public outreach activities, communication activities, and interrelation activities. These should result in more support offered to the Tubbataha Reefs Natural Park Foundation and increase their exposure to willing sponsors and stakeholders.

## 1.3 Research Questions

This study aims to answer the following questions: (1) What elements should be implemented in the game to represent real-life reef conservation efforts done in a ranger station? (2) Which ranger jobs should be included in the game to highlight the need for public support? (3) How effective is the game in raising awareness of reef conservation? (4) How effective will increased awareness be in getting players to act to support reef conservation?

## 1.4 Scope and Limitations

The game will be built using Unity 2021.3.32f1 for computers running Windows 7 and above. 3D game assets will be created using Blender, while Procreate will be used for 2D visual effects.

The target audience will be adults ages 18 to 40. There are two main reasons for this. First, at this age some familiarity with coral reefs and their function is to be expected. While not strictly required, understanding the relevance of coral reefs from the beginning should result in more investment. Second, most of the members of this age group generally have the necessary freedom to support reef conservation by personally donating, hosting online donation drives, or even volunteering.

It should be noted that due to the inaccessibility and dynamic nature of some data, such as costs of certain tasks and the state of the reef, it will be impossible to create a fully accurate representation of real-world conservation. Certain concepts are expected to be simplified as well, such as reef health and tourist management.

## 1.5 Significance of the Study

The game is primarily meant to encourage support for the Tubbataha Reefs Natural Park Foundation and will be based on the work of the Park Rangers assigned to Tubbataha Reef. Hence, the success of this research will serve to bring more attention to the reef and the organization responsible for it. This attention will translate into awareness about their work – reef conservation. Furthermore, as this game is meant to raise awareness about reef conservation, and consequently marine conservation efforts, anyone directly involved in those efforts will benefit from increased awareness once the game is deployed.

The stakeholders are not limited to marine organizations. Players experiencing the game will learn more about conservation efforts, as well as other details about the Tubbataha Reef itself, after playing through the game.

In the long-term, increased awareness will improve the situation of reef conservation in the country by indirectly helping maintain and develop reefs in the country, which could aid diving companies that make a living towards its tourism [7]. In the long-term, this will lead to increased food security and economic gains.

## 2 Review of Related Literature

In this literature review, an overview on Serious Games and their properties and mechanics will be presented to provide background and support for the game elements that will make up Reef Warden. This will be followed by discussion of Role-Taking and Empathy to develop how the properties of Serious Games can be used to create game mechanics that are aimed towards raising the awareness and willingness of a player to help the cause of reef conservation. Finally, games that have

characters analogous to the Tubbataha Rangers playing a central role will be examined to determine how to characterize the rangers in the game, as well as further refine potential game mechanics and elements.

## 2.1 Serious Games

While contentious, video games that claim to be Serious Games generally refer to those that are developed for a purpose beyond entertainment. Some of these purposes include learning, childhood development, and social change [19]. Social change in this context refers to sustained change in behavior of a society, usually seen relative to a societal issue such as domestic violence or racism.

There are several properties particularly relevant for Serious Games in the context of social change [13]. Although these are shared with 'normal' games - games created for enjoyment - these properties can be easily repurposed. In particular, the researchers will focus on interactivity, narrative, and ability to create a frame of play. There are multiple reasons for this. First, interactivity is unique to serious games, in that it is the only medium that allows a player to directly influence events. Second, narrative is important for sending a coherent social change message to the player. Third, its ability to create a frame of play - more commonly known as immersion - is important in getting the player to accept that message, the reasons for which will be discussed later. Meanwhile, focus on other elements such as multimodality is often manifested in the form of Augmented Reality (AR) or Virtual Reality (VR) technology and is beyond the scope of this research [14].

Klimmt also described several mechanisms that take advantage of the above properties, of which there are 15 in total [13]. There are several mechanisms related to the properties that were chosen. (1) Entertainment capacity of serious games increases likelihood of selection of change-related message. Delivering the message through a serious game instead of other media allows it to be associated with enjoyment. (2) As-if quality of game play weakens refusal to expose to change-related content. Some behaviors are set and tend to be further entrenched by explicit attempts to change them. Presenting the message as part of a serious game frames the entire situation as 'play' or a way to act as if in another's shoes, potentially circumventing this complication. (3) Enjoyment generates attention and interest for game world and content. Through enjoyable gameplay, the game attracts the player's attention. Increased attention would allow the player to process the game's message properly, therefore increasing its chances of success. (4) Interactivity increases likelihood of connection of content to player self. As opposed to other media where the player remains a passive observer or receiver of information, in games they have an active role in the game world, shaping their own outcomes. (5) Narrative creates sense-making framework that facilitates comprehension. Sense-making refers to the "integration of individual real-world views and knowledge into the comprehension of mediated information" [13]. This is particularly applicable to narrative,

which each player can apply sense making to. In doing so, they each find different personal meanings in the change message.

In short, there is now a list of basic requirements for *Reef Warden*. First, the game must have enjoyable and immersive gameplay. Second, the game should give the player enough agency to meaningfully determine the outcome of the game. Random generation of events should not be so crippling as to force the player into a very confined set of circumstances that would hamper decision making. Lastly, the game must have a narrative.

## 2.2 Role-taking and Empathy

Role-taking is a concept in sociology and psychology that deals with the process by which individuals imaginatively construct the perspective of others [5]. Empathy, on the other hand, refers to a person's ability to take the role of another in order to understand their feelings, perspectives, and ideas [10]. These two definitions imply an inherent link between the two concepts. That is, empathy refers to the ability to do role-taking.

### 2.2.1 The Role of Empathy

Paciello et al. investigated empathy and personal distress as factors in willingness to help following an explicit request for assistance [17]. They concluded that high levels of empathy lead to prosocial moral reasoning and inhibits personal distress. On the other hand, high levels of personal distress led to moral disengagement.

Prosocial moral reasoning here refers to the process of ascertaining whether one should help others or not; at higher levels, it is associated with helping behavior in anonymous situations, making this the desired behavior. Meanwhile, moral disengagement is the process of justifying immoral behavior. Having the game create an environment conducive to prosocial moral reasoning then becomes a goal. Empathy positively affects this reasoning, thus giving a more concrete goal for the game: Foster empathy in players.

### 2.2.2 How Serious Games Foster Role-taking and Empathy in Players

Peng et al. studied the effects of serious games on role-taking and willingness to help, specifically in the context of humanitarian aid. Role-taking was treated as the most advanced mode of empathy, and in this way would produce helping behavior. It was found that playing serious games resulted in greater role-taking and willingness to help than either game watching or text reading [5].

The game used in the study is *Darfur is Dying*, a serious game about the conflict in Darfur. Peng et al. noted several factors that influenced the positive outcome of the study. First, the game's interactivity over game watching and text reading methods played an important role. Second, multimodality was not as significant of a factor. Third, enjoyability does not necessarily

correlate with gameplay. Players found the game less enjoyable than either simply watching it or reading about it.

Thus, the requirements are further refined. First, the game must not be frustrating to play. Second, the game must put a lot of control in the hands of the player to avert that frustration. Lastly, the game's narrative does not have to be heavy, as seen in *Darfur is Dying*. Outside of the game's endings, there is no set structure guiding the player from specific points beyond 'find water'. Much of the narrative is determined by the player's actions, as seen by how the endings differ on how the player dies or what avatar they choose.

## 2.3 Park Rangers in Video Games

This section will explore video games that have characters analogous to the Tubbataha Reef Park Rangers. This is necessary for the researchers to discover which jobs would translate well into a game.

### 2.3.1 Jurassic World Evolution

*Jurassic World Evolution* is a management simulation game developed and published by Frontier Developments [26]. Players are charged with constructing and managing a theme park centered around dinosaurs, building facilities to research new technology such as new buildings or dinosaurs, attract and manage tourists for income, and expand security. These are accompanied by contracts to encourage player progression into these domains. All this is done in a limited area of an island, with the player eventually unlocking more islands that each have unique challenges and environments [16]. Progression is thus straightforward and obvious to the player.

In the gameplay elements above, park rangers are featured in a central role. The player must first build a Ranger Station, and from there rangers perform a variety of tasks and responding to various incidents like attacks on tourists and completing missions [12][26]. Park rangers accomplish these tasks in teams, with tasks assigned by the player. The rangers use a jeep for transport around the park, allowing even a small number of rangers to perform a series of tasks in a timely manner. Rangers clearly play an important role in helping manage the park.

Overall, this has led to *Jurassic World Evolution* being praised for its accessible yet enjoyable gameplay. It has, on the other hand, received criticism for its simplicity when compared to other management games [11]. Despite this, the researchers will, on a high-level, use *Jurassic World Evolution's* gameplay as a base for two reasons. First, with reference to the basic requirements of Reef Warden stated previously, enjoyable gameplay is desired. Second, *Jurassic World Evolution* portrays the rangers as fulfilling a large variety of roles, such that they are a 'jack of all trades' core to the player's progression.

### 2.3.2 Beyond Blue

*Beyond Blue* is a single-player narrative driven adventure game with an educational intent [9]. Although not explicitly stated, for

this reason *Beyond Blue* is an example of a Serious Game for education. Players experience the game as a deep-sea explorer and scientist named Mirai investigating various sea creatures and the multitude of effects climate change has had on them [21]. These are presented to the player throughout a series of dives connected by a single narrative.

*Beyond Blue's* protagonists fulfill a research role similar to that of the Tubbataha Rangers. The Tubbataha Rangers track and investigate the local species and defend the reef from human threats. Likewise, Mirai and her team are responsible for researching local species and finding or preventing the negative effects of local human activity. In implementing this, *Beyond Blue* followed a straightforward approach: During each dive, Mirai explores the area while following the instructions of her research team, scanning local species and points of interest. This is the core gameplay loop. The narrative meanwhile takes on the form of conversations before, during, and after the dives. Criticism has been levelled at both the gameplay and the narrative due to their repetitiveness [15][27]. Outside of those elements, however, the game's educational content provided by the narrative, the exploration itself, and the supplementary content (in the form of the game's mini-documentaries and encyclopedia) have received near universal praise. The game is backed by research and expert consultation [15].

What should be borrowed then from *Beyond Blue* is how the game will be focused on educating the audience to the effects of climate change, and the importance of the reef. Dialogue will be used to form more of a connection between the characters and the player. The player's team would also have members of around 6-8, and such interactions between the characters and their surroundings is what will drive the narrative forward. This will also help give the general atmosphere of the game and show the message of the negative effects of climate change. Unlike *Beyond Blue*, however, narrative will not be the focus. Higher levels of enjoyability will be provided through interesting and compelling game mechanics and diverse interactions of the characters with their environment.

### 2.3.3 Firewatch

*Firewatch* is a game mainly about Henry, a newly appointed fire lookout in a park in Wyoming. He mostly interacts with his supervisor, Delilah, who oversees another area of the park [4].

The game focuses on the daily tasks of being a fire lookout and a park employee, the importance of the job and the dangers incorporated with it by showing the emotions and expressions the main characters have towards their surroundings through their dialogue. It is very narrative driven, focusing on the dialogue and relationship between Henry and Delilah to give the player a connection to the 2 characters. The game lets the players make dialogue choices that can either build or destroy Henry and Delilah's friendship. It shows the incidents a park employee must deal with on a regular basis, from rowdy teenagers to large forest fires. The game features an

exceptionally large explorable map which contains dialogue cues to the 2 characters and interactable props and structures.

The researchers will borrow the game's usage of dialogue and the character relationship similar to that between Delilah and Henry in order to create a connection between the players and the characters.

### 2.3.4 Synthesis

Both *Beyond Blue* and *Jurassic World Evolution* do not have a balance between education and enjoyability, which is what will be improved upon to widen the *Reef Warden's* preferred audience. *Reef Warden* will also provide educational facts about the reef and show the importance of the effects of climate change and how it greatly affects the lives of the rangers and the environment they are caring for. It will also show the effects of human action to the environment and to their fellow compatriots through dialogue and character interactions that will effectively show the emotions and personalities of the characters delivering them.

## 3 Methodology

### 3.1 Game Design

#### 3.1.1 Game Premise

In *Reef Warden*, players build up their ranger station while dealing with the various threats to the reef. This is complemented by a story with individual characters. Thus, it falls under the base-building genre, albeit with story elements. Through this story and gameplay, it aimed to increase awareness of reef conservation and the efforts associated with it.

#### 3.1.2 Data Gathering

During the process of designing the game and researching on the various duties of Tubbataha Rangers, the researchers consulted with subject matter experts from the Tubbataha Reefs Natural Park Foundation. This included the duties of a ranger, resources they had at their disposal, and the challenges they encountered. During development, the researchers consulted regularly with subject matter experts.

### 3.2 Game Development

#### 3.2.1 Software

The latest LTS version of the Unity game engine (2021.3.2f1 at the time of writing) was used to develop the game. Unity was chosen due to extensive documentation, ease of use, and stability brought about by long-term support. For collaboration, the researchers used Git.

Assets for the game were created by the researchers. 2D assets and animations were done solely on Procreate, a mobile drawing app made to replicate PC editing software such as Photoshop or Paint Tool SAI. 3D assets and their respective animations were made with Blender, a 3D modelling software that can also be used to render in textures and make animations.

#### 3.2.2 Development Method

The Scrum framework was used within the context of the software development life cycle. As a process, it is both incremental and iterative, allowing for continuous refinement of requirements and a divide-and-conquer approach to development [20]. This is a necessity as changes may be made to the design on consultation. Hence, it has been praised for its flexibility and ease of use. While this framework is intended for large teams – larger than 4 - its incremental and iterative steps can still be followed.

The game was divided into a set of modules, with each providing a specific working functionality. Each of these modules were developed in a sprint at least one week in length, in consideration of the allotted development time of a semester. Reviews and consultation were done at the end of each sprint.

### 3.3 Data Collection Methods

#### 3.3.1 Playtesting Sessions

The playtesting sessions were done online following completion of the game's development. Potential testers were selected through the investigators' contact lists. They were each sent a spiel describing the research and the format of their participation. If they were interested, the researchers sent them a screening and consent form. Should they also be eligible, the researchers contacted them to determine a suitable schedule for the playtesting over a virtual platform, specifically, Google Meet. The two researchers walked them through the questionnaires and the playtesting. This ensured that the session continued in case either of the researchers experience connection issues. During the session, they administered a pre-test questionnaire, assisted with playtesting for at least 30 minutes, and administered a post-test questionnaire. When the participant experienced any connection issues, the session was rescheduled. The composition of the questionnaires will be discussed briefly in the following sections.

#### 3.3.2 Awareness

The public awareness of marine environmental threats and conservation efforts questionnaire by Easman et al., although more general in nature, was judged to be suitable for this purpose [8]. There are several sections of interest. The first section consists of a series of items that measure overall concern and action, answerable with a 5-point Likert scale. 1 indicates least concern and 5 indicates serious concern. Easman et al. noted that this section ensured honesty in answering later sections. Two other sections deal with awareness of conservation efforts proper. The first deals with general conservation strategies, like the establishment of marine protected areas, and the latter deals with specific conservation strategies. These sections have 3-point scales, going from "no awareness" to "aware of its strategy and aims". The researchers refined these items as needed to suit a reef conservation specific context. The former focused on general reef conservation strategies, while the latter was concerned with strategies specific to marine conservation areas such as the Tubbataha Reef.

### 3.3.3 Behavioral Intention

This part of the questionnaire was heavily based on the guidelines of “Constructing a Theory of Planned Behavior Questionnaire” by Icek Ajzen [1]. It was split into 3 parts based on the governing human behaviors, i.e., behavioral, normative and control beliefs. In addition, there was a fourth part which dealt with the respondent’s intentions towards reef conservation here in the Philippines. Behavioral belief focused on the questions that meddle on the attitude towards reef conservation, mostly at a rating form of 1 to 5, 1 being the least and 5 to be the most. Normative focused on the subjective norm of it, wherein it asked questions that ask if the respondent’s peers should also help in reef conservation. It followed a similar scale. Lastly, Control focused on the perceived behavioral control, or how difficult the task of giving help and support towards reef conservation in the Philippines will be for the respondent. It also used a scale 1 to 5, like Behavioral belief. The last question asked how much the respondent is willing to give help and support towards reef conservation when they are given the chance.

### 3.3.4 Game Experience

Beyond the immediate objectives of the study, the researchers were also interested in the differentiating factor of the study’s output – the enjoyability of its experience as a game. The game experience questionnaire developed by IJsselsteijn et al. was developed for this purpose [29]. It is divided into three modules – core, social presence, post-game – all of which are meant to be answered after playing the game. Each module is divided into a set of statements, with agreeability indicated by a 5-point Likert scale. The researchers used only the parts of the core module that deal with enjoyment, specifically, the positive/negative affect portion.

## 3.4 Analysis Methods

Given the research questions stated in the first chapter of this thesis, there are two hypotheses that must be investigated:

1. Playing Reef Warden increases awareness of conservation efforts.
2. Increasing awareness of these efforts correlates with increased willingness to help.

There are two relevant analysis methods for these which both fall under hypothesis testing. The first is t-test for two dependent samples. This was chosen due to an expected small sample size (<50), as well as the presence of only two samples, the pre-test sample, and the post-test sample. It has also been noted as robust, i.e., accurate even if the assumption of normality is violated. The second method is linear regression with t-test. This will be used to check for the existence of a linear correlation and its strength.

The prior stated methods presuppose that the Likert scale – an ordinal scale - is compatible with t-tests. De Winter and Dodou on studying the suitability of t-tests versus the Wilcoxon Rank Sum test noted that they are - given that discrete values are assigned [6]. Hence, for compatibility with these tests, the

researchers assigned integer values to each item in the questionnaires.

## 3.5 Summary

The researchers investigated whether Reef Warden increases awareness of reef conservation and the efforts associated with it. Playtesting was required to do so. To measure a change in awareness, as well as the effects of this change, relevant questionnaires were given before and after playtesting. Finally, to analyze the data gathered from these questionnaires, t-test and linear regression were used to check for a change in awareness, as well as the effectiveness of changing awareness vis-à-vis willingness to help.

## 4 Results

### 4.1 Final Design Overview

#### 4.1.1 Game Concept

Reef Warden is a turn-based base-building and management game, where players are given the role of developing their ranger station to protect the neighboring reef, while also increasing the capabilities of the facility to manage tourists. They will also have to conduct research to learn more about the reef and increase its protection. The game also has a story with its own characters to unify all these efforts.

#### 4.1.2 Game Flow Summary

The player starts with the ranger station, some basic upgrades, and a starter fund. They must develop the ranger station to increase the rangers’ capability to defend and research the reef. Meanwhile, the player must assign the rangers to enforce the rule of law around the reef, conduct research on it, and manage visiting tourists. The player is also able to research upgrades that help with these duties. During this process, the player learns more about the reef and the work done by the rangers to protect it. This is driven by a main story, mostly triggered by events which occur at certain points of the game. Occasionally, they must also deal with incidents such as illegal fishermen and unruly tourists. Failure to respond properly to these will cause damage to the reef. The game ends if a special technology is researched or reef health reaches 0. Following that, a story segment starts showing the good or bad ending, after which a score screen is displayed.

#### 4.1.3 Look and Feel

The main screen features an isometric camera view that the player is free to move around. It also features a mix of 2D animated effects, and 3D models for the environment, upgrades, people, and other assets. There is a hex grid over the map for building upgrades and unit action. The story screens feature 2D stills and sprites.

#### 4.1.4 Goal of the Game

The main goal of the game is to promote awareness of marine conservation, specifically reef conservation and the challenges

associated with these. There are several balancing acts the player must perform. The first, and arguably the most important, is between enticing tourists to come - sorely needed for money - and ensuring they have the right combination of upgrades and personnel to manage them. Too much of the latter will result in lower income, yet too much of the former will result in something far worse - the degradation of the reef. While most tourists in game will follow rules, as in actuality, more tourists greatly increase the odds of damage to the reef due to violations. This is although tourism exists solely to fund and promote their efforts to defend the reef. Yet as the player progresses and costs mount, they may be attempted to 'optimize', by spending reef health as if it was a currency and attracting more tourists than they can manage. This is a dangerous strategy, as there is no way to repair the reef in-game; it takes years for a reef to repair, after all.

Another balancing act is between upgrades to defend the reef from incursion and other types of upgrades since the other threats to the reef's health are in the form of illegal fishermen. Too much focus on the former may hamper a player's research work, while prioritizing the latter will slow down game progression. Like tourists, their actions will affect reef health. Less reef health will affect the player's income directly; tourists will be less likely to pay for souvenirs or tours when the object of interest is no longer attractive.

#### 4.1.5 Ranger Jobs

For the game, the researchers chose to implement the rangers' daily tasks with regards to visitors to the reef along with their research duties. These represent the most active parts of their jobs, as these deal with the maintenance of the reef and its protection against anything that may affect its state. Broadly, these are divided into three types: Research, Enforcement, and Tourist Management. Each of these types gives their relevant resources. Research duties give research points when done, Enforcement increase the security, and Tourist Management give monetary income.

Incidents, random events of varying durations representing what the rangers deal with on a regular basis, integrate these jobs into the gameplay loop. These are level based, wherein the player will experience incidents of different difficulty levels and as the narrative progresses, the difficulty of the incidents goes higher. These incidents are the most populated of dialogue from the characters, showing players the personalities, responsibilities, and mental fortitude of the rangers. Examples of these incidents include the appearance of illegal fishermen and the management of tourists.

## 4.2 Implementation of the Game

The game's core features have been finished. Unimplemented features as of the time of writing include minor random events with story dialogue. Asset replacement is ongoing for both 3D assets and UI assets.

### 4.2.1 Game Mechanics Development

The Settings tab in the Main Menu of the game has now been implemented. The options in the Settings tab to change the game's resolution, toggle Fullscreen mode, decrease, and increase Sound volume are all working as well. All upgrades that are available to be researched by the player are now functional. These help the player in various ways, from UI assists to resource bonuses. Players can now Monitor Clams to gain more research points and the action to Check the Reef's Health is now limited to the marked spaces on the map, as seen in Figure 1 below. Sound is also implemented in the game to help the player's immersion. There have also been multiple balance adjustments for different aspects of the game like ship speeds, objectives, and respawn rates.



Figure 1: Checking Reef Health

## 4.3 Visual and Narrative Developments

### 4.3.1 Dialogue

Dialogue for multiple events in the game has already been added. Aside from the dialogue present in the tutorial, there is now dialogue for specific characters during specific events that can happen in the game. The events include the spawning and inspection of tourist and fisherman boats, and dialogue for the good and bad endings of the game. Figure 2 below shows the added introductory cutscene.



Figure 2: Added Dialogue

### 4.3.2 UI Assets

Other than the basic UI elements needed, such as menu buttons, resource counts, and objectives list, initial implementation of clickable map UI elements have been added. These include the

icons to check for reef health that highlight when moused over. Below, Figure 3 shows the main screen of the game.



Figure 3: UI Assets

### 4.4 Playtesting

A newer version of the game than presented above was used for the first wave of playtesting. The only changes for this version were bug fixes. In total, there were six playtesters that participated in the first wave. Their feedback will be discussed briefly, followed by pre-test and post-test results for the constructed questionnaire.

#### 4.4.1 Feedback

Reception to the gameplay was generally positive with some caveats. In the game experience part of the questionnaire, playtesters indicated that the gameplay was enjoyable but unchallenging. Table 1 below presents the results, with scores from 0 to 4.

Table 1: Player Game Experience

GEQ Component	Mean	Standard Deviation
Positive Affect	3.5	0.28
Negative Affect	0.71	0.75
Challenge	1.04	0.84

When asked, some elaborated that the gameplay loop was engaging, but that it was too easy to obtain money or research points. Most also finished the game without reaching below 70% reef health. Much of this damage was incurred only in the last two levels, when spawn rates started to increase, and players were increasingly forced to rapidly switch between tasks.

There were also technical issues that affected the testing. Some bugs that affected progression were only found and fixed during or after sessions despite testing done by researchers before. Due to this, some sessions were not able to reach the end of the game, given the time constraints. There was also a playtester that had performance issues that greatly slowed down the game to the point that they were only able to progress until the end of

the tutorial. This was later found to have been caused by wave animations. This has since been fixed.

The rest of their concerns, however, were about UX. First, it was not always clear what the player should click next. For example, in the tutorial, one tester moved the service boat instead of the patrol boat when prompted. Second, readability was an issue. This was mainly caused by the choice of font and the formatting of information in some menus, such as the info menu. Lastly, given the length of the game, some felt that it tried to present too much information in too short a span of time.

#### 4.4.2 Awareness

**4.4.2.1 Awareness of Environmental Threats.** In the threats section of the pre-test questionnaire, playtesters generally indicated a high awareness of environmental threats. With regards to overfishing, pollution, and climate change, threat ratings were at least 4 or 5 out of 5. All three affects those environmental efforts such as MPAs attempt to mitigate. Marine Noise, on the other hand, was more varied, with scores of 3, 4, and 5. One playtester indicated 'unsure'. It is worth noting that these were not forced rankings, as in general the intent for this question is to convey the idea that these threats are equally threatening ones that marine park rangers aimed to address.

In the post-test questionnaire, overfishing and climate change were all given scores of 5. Marine Noise remained the same, while Pollution was more varied. Individual results were similarly varied; two participants had their rankings decline, three participants had their rankings increase, while one had theirs remain unchanged.

**4.4.2.2 Awareness of General Conservation Strategies.** In this section, playtesters had to indicate whether they did not know a strategy, they knew it, or they knew it and its aims. In the pre-test questionnaire, most participants generally had at least some degree of awareness of these strategies. Only 2 playtesters out of 6 at most indicated that they had not heard of these, and that was for fishing quotas. The sole exception is marine citizenship, which 5 out of 6 playtesters had not heard of at all.

In the post-test questionnaire, awareness of these strategies varied. From the general perspective, fishing quotas went from a 2/1/3 split to a 2/0/4 split [in the specified order above]. Ecosystem approach to fisheries saw an even split between those who only heard of it and those who knew its goals. Half of the participants now knew about marine citizenship. Individually, one participant showed no improvement, while five participants showed increased awareness of at least one strategy.

**4.4.2.3 Awareness of Specific Conservation Strategies.** This section is like the previous, with the prompts replaced by conservation strategies specific to the Tubbataha Reefs Natural Park. Like the above, most playtester had some degree of awareness. However, it was less than the last section. 6 out of 10 strategies had at least one playtester indicate that they did now know that strategy, for

a maximum of three. The worst offender was the TRNP Act, which had half of the playtesters indicate lack of knowledge. Awareness of these strategies generally increased in the post-test questionnaire. 4 out of 10 strategies had at least one playtester indicate that they did not know it. Some strategies had playtesters indicate that they now knew both the strategy and their goals – for example, the existence of accredited dive companies. Individually, all participants except for one showed improvement in awareness.

#### 4.4.3 Change in Willingness to Help

**4.4.3.1 Gameplay Experience.** This section deals with the overall experience the playtesters had during their testing session and their emotions towards the game. Overall, the testers felt enjoyment and content in the game. However, some found it boring and there were testers that found the game challenging, requiring more effort than anticipated.

**4.4.3.2 Thoughts on Marine Conservation Efforts.** Changes in the testers' responses on the willingness to participate in support efforts towards Tubbataha or any marine conservation effort are the focus of this section. There was an increase in the responses of the testers to share relevant information related to the conservation efforts in the participant's respective personal social media page. A slight increase is also seen in buying merchandise, such as t-shirts and keychains. The testers were much more willing to give donations to fundraising efforts, sign-up for volunteer work and organize fundraising efforts in the post-test questionnaire as compared to the pre-test. However, there was also a slight decrease in joining guided tours or dives.

The thoughts of the participants towards how such activities would help maintain Tubbataha or other marine reef conservation efforts generally increased, mostly seen on Participant 2 and 6. Almost all had no change between the pre-test and post-test questionnaires, specifically towards donating to fundraising efforts and signing up for volunteer work, although there was Participant 2 and 5 whose score decreased.

There was no change in all the testers' openness to expressing their concerns on reef conservation towards others. No change was also observed when the participants were asked about how expressing their concerns to others will help increase support for the marine conservation efforts such as those in Tubbataha.

## 4.5 Statistical Analysis

The results must also be analyzed quantitatively. For measuring the improvement in awareness, the researchers use t-test for two dependent samples to check for an increase in awareness, and a linear regression with t-test to check for the relationship of increased awareness and willingness to help, as mentioned in the previous chapter. When applicable, figures will be rounded off to three decimal places.

It should be noted that due to circumstances during their testing such as low performance, crashes, and inability to finish the

game, the researchers have excluded the data of the third participant from the statistical analysis.

#### 4.5.1 Awareness of Environmental Threats

- Null hypothesis: The mean change in threat awareness scores is equal to zero after playing the game.
- Alternative hypothesis: The mean change in threat awareness scores is greater than zero after playing the game.

With  $\alpha = 0.05$ , we perform a one-tailed t-test on the following data set. The scores seen in Table 2 below range from 1 to 5.

Table 2: Threat Awareness Score Means

Pre-test (mean)	Post-test (mean)
4.75	4.75
4.75	4.75
4.5	5
3.75	3.25
4.75	3.5

Without the third set,  $p = 0.2228071941$ . As  $p > \alpha$ , we do not reject the null hypothesis. Thus, there is no significant difference between the threat awareness scores before and after playing the game.

#### 4.5.2 Awareness of General and Specific Conservation Strategies

- Null hypothesis: The mean change in awareness scores is equal to zero after playing the game.
- Alternative hypothesis: The mean change in awareness scores is greater than zero after playing the game.

With  $\alpha = 0.05$ , we perform a one-tailed t-test on the following data set. The scores seen in Table 3 below range from 0 to 2.

Table 3: Strategy Awareness Score Means

Pre-test (mean)	Post-test (mean)
0.6875	0.875
1.6875	1.625
1.0625	1.25
1.3125	1.75
1.25	1.875

The p-value is 0.04003844443. As  $p < \alpha$ , we reject the null hypothesis. Thus, we accept the alternative hypothesis, and note that there is a significant difference in the strategy awareness scores before and after playing the game.

#### 4.5.3 Willingness to Help

##### 4.5.3.1 Change in Willingness to Help.

- Null hypothesis: The mean change in behavioral scores is equal to zero after playing the game.

- Alternative hypothesis: The mean change in behavioral scores is greater than zero after playing the game.
- With  $\alpha = 0.05$ , we perform a one-tailed t-test on the following data set. The scores seen in Table 4 below range from 1 to 5.

Table 4: Behavioral Score Means

Pre-test (mean)	Post-test (mean)
4.429	4.429
3.714	3.857
4.357	4.571
1.313	4.289
3.93	3.923

The p-value is 0.2616617163. As  $p > \alpha$ , we do not reject the null hypothesis. Thus, there is no significant difference in the behavioral scores before and after playing the game.

4.5.3.2 Relationship of Change in Awareness and Change of Willingness to Help. The relationship between awareness and willingness to help must also be verified. In doing so, linear regression is used, with strategy awareness being the independent variable and change in willingness to help being the dependent variable. Two scatterplots (Figure 1, Figure 2) were created for pre-test and post-test values.

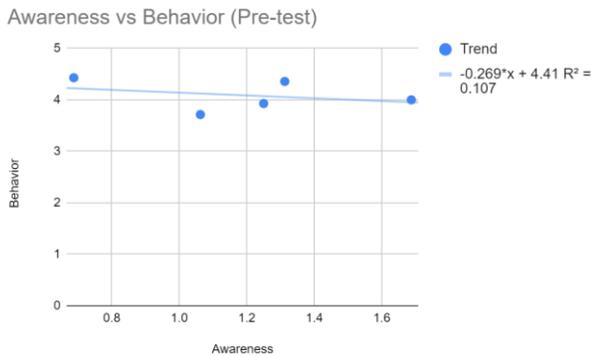


Figure 1: Pre-test Scatterplot

The pre-test scatterplot has values of  $R^2 = 0.107$  and  $R = -0.327$ , the correlation between the two variables is negative and medium, with the values being relatively distant from the trendline.

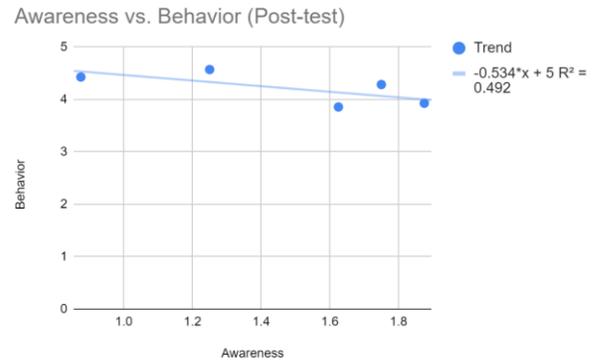


Figure 2: Post-test Scatterplot

Post-test scatterplot reveals values of  $R^2 = 0.492$  and  $R = -0.701$ , the correlation between the two variables is negative and strong, with the values being of average distance from the trendline.

4.5.3.3 Linearity of the Relationship of Change in Awareness and Change in Willingness to Help.

- Null hypothesis: The slope of the regression line for awareness and willingness to help is zero.
- Alternative hypothesis: The slope of the regression line for awareness and willingness to help is greater than zero.

With  $\alpha = 0.05$ , we perform a one-tailed t-test on the regression lines created in the previous section.

Table 5: Regression T-test values

	Pre-test	Post-test
<b>r</b>	-0.323	-0.701
<b>n</b>	5	5
<b>df</b>	3	3
<b>t</b>	-0.5997	-1.704
<b>p-value</b>	0.295	0.093

For both p,  $p > \alpha$ . Hence, we do not reject the null hypothesis. Thus, there is no significant linear relationship between awareness and willingness to help.

## 4.6 Summary

The researchers completed an initial build of the game containing all core features. Playtesting was organized with a total of five playtesters. These playtesters indicated high enjoyability but low challenge for the game. Initial qualitative analysis of results from these playtesters showed a general increase in awareness and willingness to help. Further statistical analysis, however, revealed that only the change in awareness was significant. It was also revealed that although there was a negative relationship between awareness and willingness to help, the relationship was not significantly linear.

## 5 Conclusion

This research aimed to produce a video game raising awareness of reef conservation in the Tubbataha Reefs Natural Parks to increase support for these efforts. This game focused on sharing the work experience of the Tubbataha Rangers with players.

The game also had several restrictions at the outset. First, it could only be played on PCs with Windows 7 or above. It was also targeted towards a younger audience of ages 18 to 40. Lastly, the researchers would only be able to implement a simplified representation of reef conservation. Resource costs and processes were grounded on estimates based on prior interviews with the management of the Tubbataha Reefs Natural Parks.

Meanwhile, the research itself was aimed at answering research questions presented earlier. It should be noted that these were answered throughout the document. The first and second were addressed with the certain elements in question being simplified to be able to effectively translate the real world tasks the Rangers must do to the style of our game. The third and last questions were answered with the playtesting sessions which successfully measured the effectivity of the game to raising awareness of reef conservation for the 5 playtesters. In the following sections, the answers to these last two questions will be further discussed.

### 5.1 Effectiveness of the Game in Increasing Awareness of Reef Conservation

Based on the results in the previous chapter, the game was every effective at increasing awareness of the strategies used by the Rangers and other similar environmental organizations in reef conservation but was ineffective at increasing their awareness of the threats faced by such organizations. However, it should be noted that many of the playtesters already felt that the environmental threats they had to assess were dangerous before playing the game. Whether significant impacts will be made on those less aware of environmental threats will need further study.

### 5.2 Effectiveness of the Game in Increasing Support for Reef Conservation

It was not very effective in doing so. Results revealed a generally negative relationship between the two. That is, more awareness translated to less willingness to help both before and after playing the game. This, however, could have been affected by the nature of the game as enjoyable but relatively easy. It is possible that the game did not present the urgency of the situation well enough for players to conclude that reef conservation needs more support, given their concerns regarding the difficulty. That is, players were given a false impression that while support is needed, it is not so urgent as to need their support. As the game is intended for public release, the final build of the game needs to address this issue.

### 5.3 Issues

The most important issues experienced in the creation and testing of the game were technical in nature. First, as mentioned in the previous chapter, there were bugs that adversely affected the playtesting sessions that the researchers were unable to find beforehand. These ranged from progression halting to distracting ones. For example, in one session, the game crashed right at the ending screen. Lacking time to restart the game, the ending had to be shown by one of the researchers through screen sharing. Other bugs included being unable to move units or frozen windows, which the researchers were able to work around during the sessions.

It should be noted that the researchers conducted extensive testing the week before playtesting officially started. That these bugs were not found before the official playtesting shows that these bugs were likely caused by edge cases or logic issues only evident when used by someone unfamiliar with the game. At the time of writing, these issues have been fixed.

The other main issue was balancing. Originally, the researchers had found the game somewhat too difficult, being unable to reach the end of the game due to high spawn rates of interactable boats. An overcorrection may have been made, with boat spawn rates being reduced massively without a corresponding increase in their possible good or bad effects. Resource gain was also too high; playtesters typically never ran out of resources if they did not attempt to research or build everything in one turn.

### 5.4 Recommendations

One concerning effect of the game was that although it increased the knowledge of the playtesters on the subject matter, they did not feel more inclined to help reef conservation efforts. Beyond rebalancing the game to make outside help feel more impactful, the researchers recommend that the game's user experience be further improved. Currently, much of the information about reef conservation is taught through a combination of story dialogue and map interactions. Some playtesters – those less versed in games – often asked about what certain resources would do or what certain interactions were needed to do something. This is in line with the reasoning cited in a previous chapter, that breaks of immersion are not conducive to social change in a serious game.

During the sessions themselves, a small break after finishing the game (or reaching as far as the playtester could) may have been of benefit. Due to the large amount of information the game attempts to impart to the player, from the gameplay mechanics to the educational information, the playtester could have been overwhelmed, given the short span of time devoting to both testing and gathering information from the playtester. At least one playtester complained of an 'information overload'.

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# AquaFarm Ace

## A Game on the Intensive Aquaculture Process of *Oreochromis niloticus*

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### ABSTRACT

As Aquaculture accounts for 52.4% of the fishing industry in the Philippines, it boasts potential in providing a stable source of food and livelihood. *AquaFarm Ace* is a 2D Time-Management simulation game on the intensive aquaculture process. The player takes the role of an aquaculturist as they go through the various stages of aquaculture. The game showcases hatchery, transportation, grow-out, and broodstock stages in the aquaculture stages of *Oreochromis niloticus*.

This study aims to contribute to the scholarly community of aquaculture and serious game design. The game was developed using the following tools: *Aseprite*, *beepbox.co* and *Unity 202.3.181f* and is made available through *Unity Play*. The researchers selected volunteer participants to playtest the game and answer pretest, post-test, and game experiences questionnaires to gather data in relation to the effectiveness of the game. pretest and post-test results were compared using a paired two-tailed t-test for their significance.

The results of this study show that the *AquaFarm Ace* contributes to raising awareness of aquaculture and can play a key role in highlighting its increasing demand in the aquatic scene in the Philippines to alleviate the socioeconomic problems such as food and job security. To note, playtesters retained information about the aquaculture process of *O. niloticus* after playing the game. As shown on the Game Experience survey, the testers see the game as an enjoyable experience and a potential tool to teach aquaculture.

### CCS CONCEPTS

• **Applied computing** → **Computer games**; *Interactive learning environments*;

### KEYWORDS

Serious Game Design, Aquaculture, Time Management Games

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### 1 Introduction

The Philippines, being an archipelagic state, has an abundance of water resources that spans about 2,000,000 km<sup>2</sup> of its territorial area while its land area only covers about 301,000 km<sup>2</sup> and a coastline of 17,460 km<sup>2</sup>. With this, the Philippines is considered one of the leading producers of fishery products, ranking 7th in the world. Much of its production is consumed locally [29][30].

In 2017, the mean per capita consumption of fish products was about 40kg/day. As such, the fishing industry is expected to be contributing greatly to Philippine agriculture providing food security and employment. However, as of 2010, the country has been experiencing a decline in fish production due to the exploitation of its water resources by capture fisheries and other fishing grounds [30]. Concurrently, the Philippine aquaculture scene has significantly increased during the last decade and is expected to address the shortfall in fish production as well as issues pertaining to poverty and food insecurity. Due to its dynamic production system, aquaculture has steadily contributed to the fishing industry, accounting for 52.4% of fish production in the country in 2011 [21][31].

#### 1.1 Context of the Study

Serious Game Design focuses on using games in other means other than its use for pure entertainment [26]. Oftentimes, serious games convey some sort of message in the form of knowledge or learned skill. Serious games had their applications explored in various topics in education, well-being and psychology, promotions and advertising, healthcare, politics, and cultural preservation [10][20]. As such, this paper aims to explore serious game design using the aquaculture process as a source.

With the richness of the Philippines' marine resources, aquaculture is the raising of aquatic flora and fauna in areas where they can be harvested [31]. Ayson claims that aquaculture is the fastest-growing food production sector as of 2015. Ayson further expounds that the impacts of aquaculture provide a vital role in providing food sources and income. Aquaculture provides 3.5% of the national GDP of the Philippines. This industry provides about 28.7% of the GDP production to the agriculture GDP [3][21]. In 1947, the Bureau of Fisheries and Aquatic Resources (BFAR) was established to

facilitate the growth of the aquaculture industry of the Philippines. As of 1997, BFAR ranks the Philippines as the 3rd biggest producer of seaweed that contributes to 9.3% of the world's seaweed production [30].

As discussed by Teves and Ragaza, aquaculture contributes to the fish supply that alleviates the problems of overfishing, habitat degradation, and diminishing fish stocks [30]. As fish is part of the daily diet of poorer countries in Asia, fish is one of the more widely used sources of animal protein, the demand for aquaculture products provides opportunities for profit [7].

Berquist argues that even though aquaculture has contributed to GDP growth, the practice is not without flaws. His study on the effects of aquaculture on poverty alleviation and food security illustrates the high cost of aquaculture products that only benefit rich consumers, with questionable beneficiaries of the process as poor fish farmers become vulnerable to the cost of production and challenges brought upon climate change [4][33].

## 1.2 Research Objectives

Through the aid of serious game design, this research aims to showcase the aquaculture practices and processes of the Philippines in hopes to spotlight the difficulties, challenges, and potential of aquaculture which, in turn, provide a deeper understanding, appreciation, and awareness to aquaculture. This is done by creating a game that presents the aquaculture process and highlights the challenges of fulfilling the demand for fish resources.

## 1.3 Research Questions

This paper will answer the following questions: (1) What aspects of aquaculture in the Philippines should be translated into the game? What game mechanics can be of use? How will these aspects be depicted in the game? (2) How can the game highlight the demand for aquatic resources and raise awareness of the aquaculture processes in the Philippines? (3) How can the game be engaging and fun while providing insights into the state of aquaculture? (4) How effective is the game in teaching players about aquaculture in the Philippines?

## 1.4 Scope and Limitations

The research covers Philippine aquaculture with a particular focus on the production process of cultivating aquatic plants and animals as a medium to spread awareness, expand understanding, and encourage positive actions toward Philippine aquaculture. The game encompasses the following: (1) how these processes occur, (2) corresponding challenges to these processes, and (3) the overall production of aquatic resources through aquaculture.

For this study, the researchers focused on tilapia species, particularly *Oreochromis mossambicus* that was first introduced in Thailand and Indonesia, Nile tilapia *Oreochromis niloticus*, and hybrid sub-species such as the red tilapia. Additionally, tilapia is readily available and relatively easier to

market due to its inexpensiveness, international demand, and flexibility to be sold as a product [31][35].

The 2D real-time time-management simulation game is developed using Unity 2020.3.121f. The platform for the game is restricted to the Windows platform and a single session will only feature gameplay of at most 30 minutes. The content of the aquaculture processes of the game will be taken from the open-source articles of the Southeast Asian Fisheries Development Center/Aquaculture Department (SEAFDEC/AQD) and the Food and Agriculture Organization (FAO) that are readily available on the organization's official website.

## 1.5 Significance of the Study

This paper is an attempt to depict the processes of Philippine aquaculture in a video game and could contribute to the scholarly community of aquaculture and serious game design. It should be noted that existing literature on serious game design had not covered aquaculture as a subject. Thus, the theoretical inclination of this study serves as a bedrock for future research engagements that can fortify the application of serious game design to represent the aquaculture process in a video game.

The fisheries sector in the Philippines, including aquaculture, is important to providing substantial income and sustainable employment.

In 2000 alone, the sector provided over 800 jobs [33]. Kawarazuka and Béné stated that these fish resources can potentially reduce micronutrient deficiencies in developing countries [19]. Thus, showing the potential of aquaculture as a source of nutrition. Additionally, the sector provides external export demands for fish resources [25]. In a period between 1999 and 2000, there was an increase of approximately 20 million dollars in foreign trade figures for fish resources [33].

Lamarca notes that Philippine aquaculture has strong potential [23]. However, Lopez argues that the potential has yet to be accomplished due to underlying problems such as inadequate unavailability of training and management for small-time farmers, constraints in facilities, research, and information management systems, planning, and environmental degradation [25]. Berquist supports this by highlighting the expense of aquaculture products, and the conversion of mangroves to aquaculture ponds to meet demands for these resources [3]. Given the problems that arise with aquaculture due to the demand for aquaculture products, Brummett emphasizes that the industry may find sustainability through concentrated efforts in policymaking, close attention, and participation of both producers and consumers of the industry to fully reap its benefits in a changing global society [7].

Furthermore, this study contributes to the literature on game design. It has been noticed during the literature review that there are not many studies on the representation of aquaculture in video games. Making such a game bridges the gap between using serious games as a means for educating its players the potential of aquaculture. In turn, the game made in the study hopes to inspire its players to appreciate aquaculture and make known the significance and impact aquaculture brings to society.

## 2 Review of Related Literature

This section of the research provides a literature review on the key themes that would give information on the problems presented in this research. The review of literature is divided into parts: (1) the aquaculture process, (2) *Oreochromis niloticus* Aquaculture, (3) the development of serious games and games on aquaculture.

### 2.1 The Aquaculture Process

In order to supplement the world food production process, animal husbandry and capture fisheries thrive as the main sources of animal protein. However, as the world population increases, these methods become increasingly inadequate to the actual food demand. With this, world aquaculture production rapidly develops to gain recognition as the main source of seafood production. By FAO's definition, aquaculture is the farming of aquatic organisms such as fish, mollusks, crustaceans, and aquatic plants [26].

Unlike capture fisheries, where the seafood is caught in the wild, aquaculture intervenes with the rearing process; dealing with the practice of artificial breeding, raising, and stocking of aquatic animals to enhance seafood production. This also includes individuals and corporations claiming ownership of aquatic stocks to allow internal control of the systems and to avoid the exploitation of wild aquatic animals and environmental degradation. The earliest beginnings of aquaculture date back to 2000 B.C., approximately 4000 years ago, with the husbandry of the common carp (*Cyprinus carpio*) in China. The first aquaculture monograph, *The Classic of Fish Culture*, was written around the 500 B.C. period by Fan Lai, a Chinese politician. The text contains references to structures of ponds and propagation techniques of the common carp. From then on, the practice has continued up to the present time and has evolved with the discovery of new species for culture and more advanced biotechnology. Today, aquaculture includes the following component activities: stocking and management of hatchery-produced or wild-caught fish, live or pelleted feed production, protection against predators, disease prevention and control, site selection, and aquarium management [26].

Every aquatic organism has varying body composition and growth characteristics; thus it is essential for each species to have different domestication processes, food prescription, site allocation, nutrient quality, and etc. Culture environments are typically divided into fish pens, tanks, cages, or ponds in marine, brackish water, or freshwater [31]. Fish farming can also be classified into three culture systems: extensive, semi-intensive, and intensive. Extensive farming is the earliest form of cultivation utilizing polyculture ponds to allow the stocked fish to naturally develop. Semi-intensive farming allows moderate interference with the natural environment and the regular use of formulated feed and treatment functions within medium-sized monoculture ponds. Intensive farming maximizes the stocking rate by fully engineering the growth process of the fish by feeding them with optimal feeds and controlling water nutrients and organic matter within small monoculture tanks [28]. Types of water management in intensive farming include recirculating aquaculture systems

(RAS) where water is recycled by continuous cleaning and filtration and flow-through (FT) systems where water is discarded immediately [6]. General aquaculture with market objectives follows specific phases including hatcheries, transporting, grow-out systems, fish feed production, market selection, and broodstock management [16]. This paper will be identifying the general procedures for finfish aquaculture, specifically tilapia culture. Trout, carp, milkfish, and sea bass are other examples of fish species in finfish aquaculture.

The game created by the researchers will simulate the aquaculture process to some degree. Therefore, this section discusses the five specific processes: hatcheries, fish transportation, broodstock management, and grow out systems that are implemented in the game.

**2.1.1 Hatchery.** Hatchery systems are farm laboratories where eggs are kept in a conditioned environment similar to their natural breeding process. As the basic unit of fish husbandry, the fish egg quality is a critical step for successful fish production. Upon arrival from the broodstock unit, eggs undergo quality control where a dozen sample eggs are placed in a temporary container under a microscope to check for some of the following characteristics: (1) absence of dead (opaque, whitish) and unfertilized (transparent, no evidence of cell division) eggs in the sample, (2) absence of parasites and other microorganisms, and (3) no superficial spots or dark areas which accounts for physical or bacterial damages.

The presence of any of the characteristics corresponds to a contaminated fish egg stock. Generally, egg batches with more than 10-20% abnormal eggs should be cleaned and properly discarded to avert high mortality rates during hatching and early larval stages. Common laboratory apparatus such as the microscope, pipette, watch-glass, etc. are used to check egg samples [30]. Before being transferred to the incubation tanks for hatching, a rough estimation of the approved egg numbers is required to properly optimize and pre-grade the larval rearing routines and to evaluate the expected survival rate. Since eggs collected arrive in the hatcheries days after its spawning, 75% of the collected eggs, which are often called seedstock, are still eggs while 25% are already fry. With this, the eggs are classified according to their following growth stages using egg graders [1]: (1) stage 1 eggs are freshly laid un-eyed eggs with white or light-yellow color; (2) stage 2 eggs are recently eyed eggs with darker yellow color; (3) stage 3 eggs are days old eggs with visible eyes and tails, these eggs are starting to hatch; and (4) stage 4 eggs are sac fry. The process of weighing eggs consists of gently placing the healthy eggs on a balance calibrated for egg filter tare. After this, to prevent infection and transmission of possible fish diseases, all batches of the egg are disinfected. The container is submerged in a disinfecting bath for a short period of time and before filtering and transferring to the incubation tank [30]. After disinfection, eggs are now ready for the incubation period. Stage 1 and 2 egg hatchery setup includes incubation tanks with slow water flow, while stage 3 and 4 hatchery setup utilize faster water current in trays or troughs. Incubation tanks are connected to the trays or troughs since the eggs will swim out to the top and drop along with stage 3 and 4 eggs as sac fry. During the incubation period, it is important to duplicate and maintain the spawning

environment conditions of the eggs in the incubation tanks. With mouth-brooder eggs, it is done by letting the eggs stay in motion in sterile water at a gentle temperature, aeration, and salinity to mimic the mother's mouth. MacDonald jars, or round-bottom, down-welling containers, are commonly used when incubating eggs taken from brooders as they are able to keep the eggs rotating slowly due to the constant water flow and supply. It is important to regularly check and clean the setups for the removal of any possible dead eggs and contaminants. Once hatched, developed larvae swim up the tank's water surface seeking food and get flushed in external trays, along with stage 3 and 4 fry, where they will later be transferred to the larval rearing tanks [1][27].

In the rearing tanks, the fish will be fed with powdered feed. This time period is also crucial for fry to undergo sex reversal i.e. their labile period. In most cases, especially with tilapia culture, poly sex culture tends to quickly overpopulate aquatic systems. To prevent uncontrolled reproduction, the monosex-culture technique is being utilized by reversing the sex of undifferentiated fish by administering male hormonal steroids during their labile period. In tilapias, 10-21 days from hatching is the critical time period for hormonal treatment. Producing >95% male tilapia is the recommended result of sex reversal as male tilapias grow faster than female ones. The treatment duration for sex reversal's around 20-28 days to ensure consistent and healthy phenotypic males. During this time, the sex-reversed fry will constantly be graded properly discarding abnormal fish or female fry. Healthy male fish will continue to stay in the system tanks for around 3 weeks and will be continuously fed with larger powdered feed. After the successful fry rearing, the fish will be transported for nursery and later grow-out systems [1][35].

**2.1.2 Transportation.** A general protocol when fish is being transported from one environment to another is to imitate the previous water conditions the fish were exposed to. It is important to condition the fish before placing them in a different environment. This is because fish are susceptible to becoming hyperactive, increasing their respiration rate and metabolic excretion when being transferred. Excessive manipulation and sudden temperature and salinity shifts will worsen the fish' condition [30]. Transporting may be done: (1) after egg collection to hatchery systems, (2) to take fish to live storage for breeding or growing, (3) and after harvest to bring live fish to market. For some companies, systems are located near other units for safety and efficiency reasons. In some cases, with hatcheries or broodstock, they sell their fish on other farms far from the unit. However, no matter how short or long-distance travels are, it is always required to provide special care and attention to the fish. Aside from the distance of travel, the species, age, size, and stock density of the fish being transported are important factors to consider during planning. Each species has its own biological requirements, and this is the same with the age and size of the fish [8]. To start with, when handling fish, it is always important to be gentle and precautious. Proper handling of fish involves using both clean hands with palms up from the fish's lower body, the first hand should be placed below the head with the other hand below the anus. It is also important to wear gloves to avoid contamination

and injury to both the fish and person-in-charge. Aside from physical injuries and shock from handling and packaging, transportation of live fish may also result in progressive changes in the quality of water and fluctuating concentration of chemicals such as the following characteristics [14]: (1) increase in consumption of dissolved oxygen (DO) as temperature (2) increases when fish activity increases; (3) accumulation of ammonia (NH<sub>3</sub>) excreted by fish can cause mortality as water temperature and pH increases; (4) and carbon dioxide (CO<sub>2</sub>) produced by fish as a byproduct of respiration becomes toxic and decreases water pH.

Common laboratory apparatus is used to check the quality of the water, and in some cases, veteran aquaculturists rely on empirical data. Oxygenated water used to fill the containers should be changed often when loading and moving to long distances to remove any contaminants. It is advisable to change 50% of the water every 12 hours when transporting in long distances. Sometimes low dosages of tranquilizers or anesthetics are considered to minimize oxygen consumption, ammonia production, feces, and regurgitated food production in the container. Any means of transportation can be used when transporting live fish, but special container vehicles with installed aeration-oxygenation systems, cooling systems, DO and temperature monitoring systems are often used by established companies. In most cases, polyethylene (PE) bags, which are filled with water and pure oxygen, placed in insulated polystyrene cardboard boxes act as the specialized systems in special vehicles [14][27]. Insulated boxes keep the fish quiet and in dark during transport, away from sudden noises to minimize activity. Before loading, hold fish in storage without food to empty the fish's digestive system and prevent solid build-up in the transport water. Fasting duration depends on water temperature and species. After fasting, fish should be treated 12 hours before any transport (if more than 5 hours duration). Quantities of fish can be calculated via equivalent-volume methods for larvae and fry and counting and weighing based on average for larger fish.

When storing fish in PE bags, usually done with fry and fingerlings, quality water is used to fill one-third of its total volume before gently placing the fish inside. Compressed air (for travel time less than 20 hours) or pure oxygen (for travel time more than 20 hours) is used to fill the volume. The top of the bag is closed before a pressure tube from a pure oxygen gas container is pushed inside. Before inflating, the bag must be deflated before filling up with pure oxygen for 20-30 seconds. The top is then twisted tightly and knotted. A second bag is then used for additional safety and sealing of the initial PE bags. Transportation should be scheduled at night or early in the morning to avoid sunlight and an increase in temperature. When driving, it is important for the transport containers to stay in motion so that there would be regular agitation to help increase DO content. Stops should be limited to 15 minutes at most. During prolonged stops, transport water must be changed. The exchange must also happen if fish start to exhibit abnormal behavior such as going up the tank/bag instead of floating at the bottom. In cases when DO content goes down during transport, it is up to the transporter to provide supplementary DO. A 12-volt aquarium air pump can help add atmospheric oxygen into the water to increase agitation in the

surface water. Pure oxygen stored in bottled compressed air and a medical pressure regulator can also be used to improve DO content. At this point, it is also important to grade the transported stock for any parasite-infested or injured fish. Irregular swimming and behavior as well as darkened color indicate weak fish and should be removed immediately. If the number of contaminants or weak fish is high, then the population must be put on hold until complete recovery. Prior to loading and unloading, the fish are counted and assessed to calculate their total biomass, survival rate, and to evaluate the rations accordingly. Upon grading, fish must be acclimatized to the new tank environment by letting the PE bags float in the receiving tank for about 20 minutes. This will help the fish to be adjusted to the local temperature. To condition the fish with the water quality, sealed PE bags are opened and gradually add receiving water for about 30 minutes while afloat. Once conditioned, fish can be let out into the tanks [14].

*2.1.3 Broodstock Management.* A properly managed broodstock unit is necessary to ensure quality seed stock for any aquaculture system. Broodstock refers to the matured fish used for breeding to enhance fish egg quality and quantity. It is important for spawning units to be kept separated from the hatcheries to avoid disturbance and contamination. A properly dimensioned broodstock will warrant a definitive supply of fish eggs. Prior to breeding the fish, the company or individual must first send out a request containing the production target information. This includes the seasonal delivery target timeline, desired quantity, and quality of the species' fry. This information will help the broodstock unit to plan out the latency period, spawning, hatching, and maturation of the fish eggs coveted. The broodfish, or parent fish, may come either from the wild or from broodstock selection during maturation. Some broodstock units prefer wild fish to retain the fish' natural characteristics that might have been altered using farmed fish. However, farmed fish allow units to enhance stock quality production and control possible infectious diseases. Thus, wild fish are often quarantined and conditioned for at least 6 months before being used [1][27].

When selecting suitable broodfish from the wild, aquaculturists often follow empirical criteria with the following characteristics present in fish breeders [27]: (1) no abnormalities in body shape and color, (2) absence of skeletal deformities, (3) absence of wounds, infections, parasites, etc (any external or internal deformities), (4) healthy and normal behavior when swimming and eating, and (5) best growth and quality rate within its age group (not necessarily the largest). When catching wild fish as potential breeders, the best way to capture it would be to use fish barriers and traps as fish usually follow their migratory instinct. Mesh nylon nets are also advisable to prevent skin and scale damages. A routine for every transfer of fish, it is important to imitate the fish' previous conditions with regards to its water quality, temperature, aeration, and container size. When handling the broodfish, one should be gentle and careful to minimize stress and possible injury from spiky fins. After suitable fish breeders are captured, they go through the quality control check. The quality control check includes the process of weighing and sex identification. The selected stock is gently transferred to the

quarantine area to receive prophylactic treatment to medicate and prevent any spreading of parasites or diseases. In case the captured fish fail the quality control check, contaminated fish gets discarded while the others get sold. Approved fish will undergo further quarantine and treatment before joining the existing rearing units [27]. However, some companies prefer hatchery-produced fish breeders as these exhibit artificially controlled characteristics. If such a decision is made, the broodstock unit orders a fry or fingerling batch from the hatchery which didn't go through the sex reversal stage. After this, the fish will go through the nursery until they mature. For example, Tilapia fingerlings are fed with 3-7% of the biomass with 25-30% crude protein 2-3 times a day. As with all fish rearing, water quality and equipment must be monitored and maintained regularly. After four months, fish with the best growth quality (often the large individuals) are selected for potential breeding. After selection, males and females are separated from each other before the preparation of spawning tanks where they are grouped together based on the prescribed sex ratio [1].

During spawning season, selected broodfish batches will be moved to spawning units. Open ponds, tanks, and hapas are commonly used as rearing facilities for broodstock management as well as hatchery and fingerling production. Spawning tanks can be made from fiberglass, plexiglass, epoxy-painted reinforced concrete, fiber-reinforced plastic, or marine plywood with a common water capacity of 5 cubic meters. It should be circular with a flat or conical-shaped 1-meter-deep bottom. In Asia, hapa net cages are often utilized in both ponds and tanks for maximum yield and quality assurance. All culture tanks, water circulation and quality is of great importance. Temperature, salinity, and buoyancy are all gradually monitored to avoid abrupt changes in the local environment. Tanks should also be quiet and undisturbed as male fishes often get territorial. Different species have different stocking rates as well as rearing requirements such as sex ratio and maturation stages. For all breeding systems, all equipment must be sterilized and examined in accordance with rearing standards [27]. From the broodstock selection, males and females are taken one at a time following the prescribed sex ratio. Males are often placed inside the tank to aid them to establish their territory prior to defending and attracting the females. Two terracotta pots, or clay flowerpots, are often used as possible breeding grounds for the broodfish. For fishes like tilapia, this is the precise pattern they follow. Female fish lay eggs inside the pot before leaving them to the male fish to be fertilized. After this, the female will pick up the fertilized eggs in her mouth. This pattern will continue until the female is no longer able to hold out eggs in her mouth. In some cases, brooding involves hormonal treatment instead of natural spawning. After spawning, female fish are then collected from the spawning tanks. Eggs are collected from the female's mouth carefully by hand, opening the female's mouth and gently dipping her mouth into transport containers, releasing the eggs. These eggs are then transported to the hatchery units for artificial breeding. After the eggs are harvested, the female broodfish is transferred to a different tank for rest and recuperation. This broodfish can be used in future spawning sessions after 2-3 months and must be cared for regularly [13].

**2.1.4 Grow-out Systems and Market Selection.** With high quality seed stock, grow-out systems will require intensive quality control checking at every stage as it would generally require consistent monitoring of the juveniles or fingerlings. At this point, collected fry from the hatcheries can be placed and nursed in concrete tanks following the same transporting protocols as before. Like broodstock units, materials often used for tanks are concrete or fibreglass. Tanks are often circular, rectangular, or octagonal and should have smooth surfaces with flat or conical-shaped bottom to prevent injuries, resistance and increase ease of cleaning. Traditionally, rectangular troughs are used to store fish stock [8]. However, circular tanks are gaining popularity for their self-cleaning prospect. Circular tanks also offer quality flow characteristics and conditions. Circular tanks can have a diameter of 12-100 ft and 4-5 ft in depth. Rectangular tanks have a 30:3:1 length to width to depth ratio for optimal flow conditions though circular tanks are often recommended. Depending on which technology the intensive fish farm chooses to implement, there's a variation on the required equipment that the farm must take into consideration. FT systems require drains for removal of water and waste, overflow standpipe for controlled water levels, and screened drain lines to prevent fish from escaping. Water exchange is a crucial aspect of tank culture to regulate water quality. Aeration devices are often required for DO to renew the oxygen supply of the tanks. It is advisable to maintain 5 milligrams per liter DO for good fish growth. As water exchange occurs frequently, paddle wheel aerators, agitators, blowers, and pumps are used to aerate the tank system. It is important to study the fish behavior and adjust the aeration system accordingly as different species consume varying amounts of oxygen at a given time. RAS also applies FT aeration systems but with lower exchange rates. Since RAS recycles 90-99% of the cultured water, cylindrical clarifiers with a conical bottom attached in the center drain remove solid wastes from faeces and food waste production like gravel vacuums work in aquariums. Biofilters consisting of self-supporting stacks of honeycombed modules are used to monitor organic wastes such as balancing ammonia production rates with ammonia removal rates [13].

Once conditioned, the fingerlings will constantly be fed and later on sorted by their size protocols. These procedures are to be repeated until the fish are ready for harvest. Two methods can be used to harvest fish for market. (1) Total harvesting indicates the drain-down and complete gathering of the mature fish months after initial stocking. (2) Partial or selective harvesting involves picking out large fish on initial harvesting schedule and leaving out the smaller fish to grow for the next harvesting schedule. This may also lead to total harvesting after 2-4 weeks of time of selective harvesting. Depending on the demand of fish in the market, it is important for the aquaculturist to choose between total or partial harvesting. The process of harvesting, whether total or partial, includes the use of seine and letting the fish follow their migratory instinct to be caught. As usual, it is important to minimize stress and shock induced when fish are being harvested, and so fish should be harvested in cooler conditions. Harvested fish are then transported to a processing facility or holding cages before

being transferred to marketplaces. After every harvest, tanks should be cleaned and drained to prevent contamination and other bacterial accumulation. This is also to prevent cannibalism of current stock from subsequent spawns [17] [34].

## 2.2 *Oreochromis niloticus* Aquaculture

Tilapia is one of the most important fish produced in the Philippines. It is a major component of the Philippines' subsistence fisheries and aquaculture due to its prolific nature. Compared to other culture fishes, domesticating tilapia is a simple and efficient job as it is naturally fast-growing and adaptable, requiring low investment for fish farmers [17]. Tilapias originated from Africa and was brought to the Philippines in the 1950s. Traditionally, tilapia was grown in poly-sex culture dug out ponds. This type of artisanal fishing hindered the initial growth of the large-scale and commercial production as tilapias were primarily susceptible to rapid breeding, causing overpopulation and cannibalism in the ponds, which then resulted in poor profitability and reliability for the fish. From then on, researchers developed innovative solutions such as farm-based genetic selection in breeding, manual sexing or sex reversal of tilapia fry to ensure all-male fishponds, and other modification in the biology of the species. This allowed tilapia to be one of the most consumed fish in the world [17][34]. In this paper, the researchers explored the classification and aquaculture process of the tilapia species, specifically the Nile tilapia, or *Oreochromis niloticus*. This is because tilapia, compared to other culture species, has ideal characteristics optimal for introductory aquaculture. Aside from their fast growth and breeding techniques, they are generally euryhaline and have a tolerance to adverse conditions such as low DO concentrations, which makes it possible for this group to inhabit a wide range of water conditions [17].

**2.2.1 Hatcheries and Broodstock Management.** Tilapia hatcheries follow general protocols and procedures of finfish aquaculture. Tilapias are mouthbrooders which means that the fish eggs are kept in gentle motion. During the (intensive system) brooding period, the male tilapias nest in terracotta pots in preparation for courtship and reproduction. At this point, the male will be territorial and grip male intruders by the mouth to push them out of its territory. Female tilapias attracted will mate with the male by swimming in circular motion with the male butting the genital tube of the female. After a few hours of mating (approximately 200 eggs depending on her mass. A 100g female tilapia can spawn 250-400 eggs. Immediately after spawning, the male tilapia sheds sperms (milt) to fertilize the eggs inside the terracotta pots. The female tilapias will then collect the fertilized eggs in her mouth for incubation. In the natural process, the female tilapia will not feed and restrict its breathing as she incubates the egg.

After around ten days, the female tilapia will allow fry to swim out of her mouth forming a school. In artificial hatching, eggs are immediately collected from the female tilapia to be graded and incubated in hatching jars. Prior to hatching, artificially bred eggs must undergo weighing and disinfection to prevent any major loss during the following rearing stages. For tilapia, 40% formalin, potassium permanganate, and acriflavine are the most common disinfectant used. It is important to monitor the water temperature as the time of hatching generally depends on which the incubation tanks are set in. After hatching, the fry (swim-up fry at this point) will stay in trays for its yolk sac absorption before having its sex reversed. After the sex reversal period, the fingerlings will stay in nursery tanks for 2-3 months. Later, it will be transferred to the grow-out tanks for 5-6 months.

**2.2.2 Sex Reversal.** As mentioned, tilapia is an efficient choice in aquaculture systems due to its productive nature. A fish farm can employ general aquaculture techniques with low investments and can still produce a profitable amount of quality fish. The major downfall of tilapias is its fast-breeding nature that makes it susceptible to size disparity and overpopulation in ponds. Therefore, it is important for commercial farms to culture the fish in monosex ponds and let the fry undergo genetic manipulation such as androgenic sex reversal to produce male fingerlings. Male monosex populations are generally required as male tilapia grow twice as fast as female tilapias. Fish farms applying this technique must take extra precautions during hormonal treatment as genetic manipulation might have minimal adverse effects to humans when consumed [35].

With tilapia, the day after hatching is the critical time for administering male steroids to the gonadally undifferentiated fry. The labile period for *O. niloticus* is 10-21 days. 17-methyl testosterone (MT) is the most common steroids used in sex reversal. The process includes adding a 60ppm dose of MT in the feed of tilapia fry i.e., 60 mg 17-methyltestosterone per 1 kilogram of feed. The process begins with preparing the stock solution by weighing 500 mg of 17-methyl testosterone (MT) hormone and measuring 1000 ml of >95% ethyl alcohol in a bottle. MT is carefully dissolved into the alcohol bottle. Stock solution is often stored in the 40-60 Celsius range that can last up to 6 months. To prepare the actual hormone solution, mix 120 ml of MT stock solution, 120 ml of 99% ethyl alcohol and 10 g of vitamin C into a beaker. 1 kg of powdered fish feed is prepared in a plastic container ready for mixing. If not done by a mixing machine, the solution is transferred into a spray bottle. The solution is carefully sprayed and mixed into the powdered feed a little at a time until all solution has been added. The feed is then sieved to ensure there are no lumps. Fish feed is often dried at room temperature. If stocking, seal in a plastic bag or box and store in the fridge at 40-60 Celsius for up to 21 days [1]. This ensures >95% male tilapia population

during the grow-out phase. It is important to wear clean latex gloves during preparation as to not contaminate the fry feed. Solution must be fully and thoroughly mixed in the feed, and no lumps should be present. In case when fungus grows, throw the feed immediately. Fry feeding must be conducted five times per day at 08.00, 09.30, 11.30, 13.30 and 16.30 hours. In a span of 21 days, the fry must be fed 15.6 per day during its initial application up to 89 g per day nearing the end of the labile period. The initial feeding rate for fry is 20-30% body weight daily which decreases to 10-20% by the end of the sex reversal period [1]. In case the aquaculturist is unsure of the hatching schedule, fry can be graded through 3.2 mm mesh fish egg grader to filter out >14 mm fry, which are consider too old for sex reversal [5].

**2.2.3 Broodstock Selection.** Selecting broodfish is a careful job as a quality broodfish ensures a quality seedstock later on. For tilapia, the criteria for broodstock selection are as follows: (1) body thickness 2-2.5 cm, (2) body girth of 4.5-5.5 cm, and (3) absence of physical abnormalities. After selecting the best fish in the group, is important to check the sex of each fish since there is a prescribed stocking ratio in spawning tanks. Male tilapias are often larger and brighter in color at adult size. To identify through its genitalia, gently hold the fish (as per handling protocol) and flip them to their stomach. Presence of only two openings; the first being the genital papilla, the urogenital, and the second being its anus. As such, females are smaller and less bright in color. There are three openings for female tilapias; the first being its uro-genital, the second being its ovipositor, and the third one is the anus. It is to note the males have pointed papillae, while females have rounder papillae. For tilapia, the best stocking ratio is 2-3 females for every male [11, 34].

## 2.3 Serious Games

Although most video games are designed to entertain, serious games are pieces of software that combine a structure of video games with a non-entertaining purpose [10]. Various applications of serious games were developed particularly for education and for healthcare.

Application of serious games was found in education with the aim to teach. An early iteration of which was *The Oregon Trail*, a text-based educational game that presents the situation of an American pilgrim in 1848 trying to reach Oregon while encountering challenges on the way. This game has spawned several sequels and spin-offs in the 1990s and is still available today through ports to mobile. Versailles 1685 pioneered historical and cultural narratives merged with gaming [10].

Healthcare applications in serious games emerged such as *EndeavorRx* which was an FDA-approved treatment for patients suffering from ADHD [2][36]. Captain Novolin introduces diabetes management which allows players to play as a diabetic superhero that needs to maintain their health while fighting enemies. Although Captain Novolin was not classified as serious games on conception, Lieberman analyzed

their impact on children for Captain Novolin which resulted in these children having better management against diabetes [10][23].

The researchers aim to mimic the applicability of serious games. It keeps in mind that the game needs to be entertaining but offer intrinsic metaphors to players that provide learning opportunities.

## 2.4 Games on Aquaculture

Among games that feature aquaculture, two games stand out. Both games show promise on the resource management aquaculture but lack in showing each step of the process of aquaculture. These games are more focused on the management of the farm than showing the realism of the process of the aquaculture. of involving other members of the community in the rehabilitation efforts.

First, *AquaKultur*, dubbed as the first-ever aquaculture simulation game, has inspirations of resource management games such as *Theme Park*, *Theme Hospital*, and *Sid Meier's Civilization* [12].

The gameplay features fast-paced farming once the fish eggs are placed, they will grow in about 2 minutes. The game shows realistic elements of managing the environmental impact as an effect of the process. Additionally, there are minigames inside the main game itself such as cleaning the nets under a time limit [12].

The researchers adopt the minigame aspects of the game to portray the various tasks in the process for maintenance. The game focuses more on the specific step-by-step process of aquaculture.

Second, *Aquaculture Land* sets the player in an environment with the starting land which situates players to regulate the various components of ponds that affect the quality of fish harvested as they grow. The player starts with a plot of land, a worker that does the various tasks of the game and starting money to expend [24].

The player can incorporate machines that help in the process that regulate the needs of the fish. The game features levels of micromanagement of employees, growing and maintenance, breeding, harvesting, and selling the fish. In particular, the game has a quest system for selling fish directly or fulfilling requests from customers. As the game is still in early access, the game still lacks a lot of features especially the post-processing aspect, and only features extensive, and semi-intensive fish farming of several featured fish species [24].

The researchers aim to mimic the top-down perspective view of *Aquaculture Land* in terms of the look-and-feel of the game and the mechanics of order systems. However, the game features a more intensive approach to the processes of aquaculture.

## 3 METHODOLOGY

### 3.1 Background Research

Prior to game development, a thorough review on the intensive aquaculture process of *Oreochromis niloticus* species as the process of growing specific species have their own nuances specific for their respective species was done. The research was integral to accurately depict and represent each needed process of tilapia culture in a game. A subject matter expert specializing in aquaculture was consulted to aid in the depiction of each process.

### 3.2 Development

The game assets were created using *Aseprite*. Sounds for the game were created using *beepbox.co*. *Discord* was used for project management. *GitLab* was used for version control.

The single player 2D time management game was developed using *Unity 202.3.181f* and is made available through *Unity Play*. A detailed version of the mechanics and features.

The development process will be split into several sprints where each sprint will focus on a single component of the game. As such, the scrum development cycle will be used as it provides flexibility, saves costs, and iteratively easy to add features [22]. At the end of each sprint, each iteration of the game was provided feedback that pertains to the necessary changes.

### 3.3 Testing

To gauge the effectiveness of the game, play testers above the age of eighteen (18) are invited to participate. Recruitment of play testers was through social media, particularly in *Facebook* and *Twitter*. Play test sessions will be held online through *Unity Play*.

Before playing the game, a pre-test was used to determine what the players know about aquaculture. The pre-test questions objective information about the aquaculture process and ask open-ended questions about the importance of aquaculture. The testers will be asked to rate their knowledge of aquaculture.

The game includes several aspects of the aquaculture such as its different phases and processes with each playtest session lasting up to 40 minutes, or when the player finishes all the stages of aquaculture. Each tester was asked to play through the game only once. After the playthrough, they will be asked to answer a post-test.

The post-test was given to determine what the tester has learned about aquaculture and asks whether the tester has become more knowledgeable about the aquaculture process and whether or not the game raised awareness regarding the demand of aquatic resources and aquaculture in the Philippines after playing the game and rate the effectiveness of the game in teaching the aquaculture process. The same objective questions from the pre-test were given.

A game experience questionnaire was also given to the testers as part of the post-test to gather data on whether the game was engaging and fun.

The results of each test and evaluation were compared before and after the playthrough through comparing their knowledge on the following: (1) aquaculture, (2) the demand of aquatic resources, (3) the aquaculture process, (4) tilapia culture, (5) importance of aquaculture before and after playing the game by the use of a paired t-test. The responses for open ended questions were noted and used to determine what knowledge and insights were gained from the game.

## 4 RESULTS

### 4.1 Mechanics

At the start of the game, the player must input their name and choose between a male or a female character. This element advocates for gender inclusivity in the world of aquaculture. Upon receiving the message from a quality control officer, the player proceeds to start the actual gameplay. There are 5 stages in the game which correspond to the 4 phases of aquaculture, mainly the hatchery, transportation, grow-out systems, and broodstock selection. The transportation process is divided into two in-game stages mainly for its loading process, and inside the vehicle process. In an individual phase, the player will have a task list that he will have to complete within a certain amount of time. Different phases have different tasks and stations around the map. Each of the tasks is accomplished by either using the interact button, waiting for the fish to grow, or completing a short minigame. The goal is to pass through the quality control officer to move onto the next phase. At the end of the stage, the final score received will award the player points. As the player progresses, they can move to the next phase of aquaculture.

At the beginning of the Hatchery stage, the player receives one seedstock (collection of fish eggs) from the receiving station. Firstly, the player must place the eggs in the quality control station where he will be grading the fish eggs for any possible infested batch. A mini game screen will pop up at this point where the player must quickly identify the contaminated samples to be discarded. After this stage, the player weighs and disinfects the seedstock by holding the interact button. The player then transfers the seedstock to the incubation period for hatching. At this point, the player must wait until the eggs hatch. Meanwhile, several seedstock arrive at the receiving station and the player must manage his time in grading the stock as well as making sure to collect the recently hatched fry from the incubation trays. The player then transfers the fry in the sex reversal station. While in the sex reversal station, the player waits until a "feed" notification is available before he can feed the fry by clicking the interact button; this will happen multiple times and it is up to the player to manage his time. The

player is given a grace period to click, and if he fails, a deduction will be made. By this period of the stage, the player must be managing multiple seedstock at once. After the sex reversal station, the player transfers the collected fry in the grading station. Grading is the final station in the stage where a quality control officer inspects the collected fry. Grading depends on the initial quality of the seedstock minus the possible deductions from missing timed actions.

In the Transportation phase, the map and stage are divided into two maps. During the first map, the player must collect the fry in the receiving station and transfer it to the filling station where a meter appears to indicate the water levels. Next, the player must go to the oxygen station and hold the interact button, making sure that the oxygen fills up to only the PE bag. After making several bags, the player then moves on to the vehicle. For the second phase, inside the vehicle, the player must maintain its speed by constantly monitoring the driver through the screen using the hold button. While the player keeps in check with the driver, the player must also monitor several bags at once. A notification pops up in the bags indicating: (1) abnormal swimming, (2) increase in ammonia, (3) increase in carbon dioxide, and (4) presence of parasites. When a notification pops up, the player must attend to the bag by pressing the interact button. The player constantly monitors both the driver and the bag until the destination is reached.

The Grow-out Systems and Market Selection stage is primarily like the hatchery stage with some modifications. The player initially takes the PE bags from the receiving station. The player places the fish bags in tanks. It is important to only let the fish out once after conditioning them. Upon conditioning, the player places the fish in their respective grow-out tanks. Once again, the player may play the feeding mini game similar to the sex reversal station in hatchery. Different tanks represent different methods of harvesting. In total harvest, the fish will be collected in one single order. In partial harvest, the fish will be harvested one at a time until all have been gathered. There are different containers depending on the tanks that the fish will be stored at, and it is the player's responsibility to match the correct container to its respective tank. After each order, the harvest collection data is represented through a piece of paper that will be logged in the computer system.

In the broodstock unit, the player receives healthy quarantined fish from the receiving station. The player then separates female fish to male fish by playing a mini game that lets him identify the fish through their genitals. Pointed "V" openings for male, and "U" openings for females. The player places fish in separate spawning tanks according to the sex ratio and waits until the female fish hold her eggs in her mouth. Once it is done, a notification will pop out from the tank indicating that the eggs are ready for collection. These processes are done while the player feeds (similar to the previous stages) the potential/resting brooders in the other

tanks. After spawning, the player must log it in the AquaFarm Ace system.

#### 4.1 Aesthetics

The visual graphics of the game were created with the intention of engaging the players and helping them immerse themselves into the aquaculture experience. The design aspect of the game was based on old Gameboy Advance RPG games such as *Pokemon*, *Harvest Moon*, and *The Legend of Zelda*. The game allows the player to control a 2D character from a non-isometric third-person, overhead perspective. The design specification follows an 8x8 pixel tiling scheme with a limited color palette for a clean aesthetic. The idea for the game design was to generate the emotional response of comfort, ease and nostalgia, and to simplify the complexity of the aquaculture process for better interpretation and retention.



Figure 1: Character Design

The game is set in the Philippines and is centered around the Philippine aquaculture of the Tilapia fish. As you can see in the figure 1, the character designs are inspired by the look of the native Filipino. Despite working inside the laboratory, the artistic choice of including the Filipino *salakot* is due to the goal of representing the Filipino culture, especially those who work in the agricultural sector. With the simplification of the actual processes in the game mechanics, the aquaculture facilities, stations, and items were also reduced to follow the 8x8 tiling scheme. All design assets follow the similar color pattern wherein the top portion of each station or item have lighter shades while the bottom portion have darker ones. Light edges give definition to the items to imitate the real-life light shadowing.

An AquaFarm Ace computer system concept was implemented to simplify some of the processes in aquaculture. To minimize the characters, mainly non-playable characters, being added to the game, the developers decided to let a computer system handle most of the communication and dynamics of the game. The character customization, introduction, tutorials, and level summary all utilize the same computer system theme to give the players information.



Figure 2: User Interface: Panel Template

Figure 2 mimics a desktop with tabs open, but the player can also quit the said panel by clicking the 'x' icon on the corner left on the top of the screen. Additionally, at every stage of the game, a corner top character information is displayed. This component allows the player to track his or her progress through the score section as well as track the timer that counts down.

Throughout the entire game, the player interacts with several stations inside the map to pick up the items needed for the next station. Seen in Figure 3, the hatchery stage has five (5) items that correspond to the initial or product of each station. This type of collection can be seen in all stages. Since the fish must always remain underwater, the items are either properly sealed polyethylene (PE) bags, trays, or containers filled with water. The hatchery unit map imitates real-life hatchery laboratories with designated receiving and quality control stations, sinks, incubation jars, and fish fry tanks.



Figure 3: Hatchery Items



Figure 4: Hatchery Map

In aquaculture, hygiene and organization is of utmost importance to prevent any contamination that might spread bacterial infectious diseases to the fragile fish. Tiles are similar to ceramic tiling used in laboratory flooring to enhance the clean look. The entire map is divided into three rooms where

the player must navigate through the entire process. This aims to add challenge and movement for the player.



Figure 5: Bad Eggs and Good Egg (Right)

As mentioned in the game mechanics, the hatchery unit begins as the player receives the seedstock, or fish eggs delivered to the unit, are stored in properly sealed polyethylene (PE) bags. These bags will be opened for quality control before being transferred to different containers pertaining to which station they have just completed. The entire stage revolves around waiting and processing the items in each station, so a top-down perspective was implemented. However, a zoomed-in view of the quality control station was implemented to offer more information regarding the fish eggs i.e., the player plays a mini game where he/she is tasked to dispose of bad eggs. Bad eggs are classified to be dead, unfertilized, parasitic, or damaged. Assets are designed as opaque, whitish, or with superficial spots or dark areas. Good eggs are clean with no other accents. This is seen in Figure 5 where the rightmost egg is plain yellow. Figure 6 imitates a shot of fish eggs placed in Petri dishes for counting and quality control. The right Petri dish will store the good eggs, while the left Petri dish will store the bad eggs for disposal. The frame of the minigame is similar to that of a monitor screen. In line with the theme that the Aqua Ace Farm has a computer system where data is recorded, the mini game screen acts as if it is a video recording of the disposal of the bad eggs for recording purposes.



Figure 6: Hatchery Mini Game Station

The first part of the transportation stage showcases the loading system of the fish fry to the grow out systems. The entire stage is set in the beach side with wooden counters to fit the Philippine tropical scenery. The player **must** move around the beach to store the fish fry in PE bags properly filled with the

right oxygen to water ratio. The final station for this station will be loading the PE bags inside the AquaFarm Ace truck.

The second part of the transportation stage highlights the actual transportation process inside the vehicle to the grow out system. It has a portrait orientation as opposed to the previous landscape orientation to give emphasis that the player is inside a moving vehicle and has limited space and capacity. The loaded eggs are stationed at the side of the vehicle with boxes in the middle for transport. After preparing for transportation, the player has to keep the driver and the fish in check. A monitor at the top-center of the map signifies this interaction as the Aqua Ace Farm accepts processing data through its computer system.



Figure 7 : Transportation - Loading the Fish



Figure 8: Transportation - Inside the Vehicle

Notification assets are used to alert the player whenever the fish needs tending. Whenever fish gets transported, they enter a very delicate state which is why farmers must always keep alert in case any of these symptoms pop up as a notification seen in figure 9: (1) abnormal swimming, (2) increase in ammonia, (3) increase in carbon dioxide, and (4) presence of parasites.

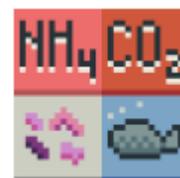


Figure 9: Fish Notification



**Figure 10: Grow-out System and Market Selection**

In the aquaculture process, the grow out phase is the longest production phase where the fish fingerlings mature to adult fish for market or broodstock selection. The design of the place was strayed to the initial hatchery unit where the tiles had a blue hue to indicate that the player is now in a different location after the transportation sequence. The flooring followed a more earthy and wooden tone similar to the traditional fishery units in the Philippines. The receiving and conditioning station is separated from the tanks by a staircase to add more depth to the map. Grow out system laboratories are filled with multiple tanks for fish development. In the AquaFarm Ace game, the developers decided to reduce the number of tanks given the objective to simplify the process. Each tank represents a different harvest procedure, such as the total harvest or the partial harvest. The broodstock system in any aquaculture process is the stage where mature fish are maintained for breeding purposes. The eggs collected from this stage are the ones received in the hatchery unit. The map is designed to have similar design aspects to the grow-out system denoting that the grow-out and broodstock units are in similar settings.



**Figure 11: Broodstock Management**

The broodstock stage has a simple architectural layout, given the directness of the process. There are multiple tanks for the breeding and spawning phase as well as a tank for receiving and picking the broodfish. Like the hatchery unit, the broodstock management system also has a procedure that was turned into a mini game. In Tilapia fish breeding, there is a recommended ratio between males and females to control reproduction for maximum efficiency and effectiveness. Identifying and separating the fish is a tricky process. A common reminder for the fisherfolks is that female fish have a

'U' shaped genital, while male fish have a 'V' shaped one. Inside the game, genitals were drawn with U or V shapes with pink and blue colors for female and male respectively as seen in Figure 12.



**Figure 12: Female (top) and Male (bottom) Fish Assets**

### 4.3 Dynamics

The game offers five different levels, all a prerequisite of the former, before ending one playthrough. The overall gameplay challenge revolves around the time pressure of two (2) minutes per level aside from the hatchery unit with three (3) minutes. The idea is that in two minutes, the player must go around the map and process the steps involved in the corresponding aquaculture phase. Hatchery had a minute more than the other stages to let the players have more time to get used to the controls as it is the first stage. With the help of the tutorials, the player must navigate through the level and retain information regarding the aquaculture process to accurately complete the task. It prompts the player to be excited and focused with their movement and time management in order to reach the highest score possible. At the end of every stage, the player receives a short message regarding how well he/she has achieved. The game has inspirations on games such as *Overcooked 2*, and *Among Us*, where the player needs to go to do simple minigames or tasks that would progress the game and *Cooking Mama* for the feel of being friendly and the sequential steps that are needed to progress into the game.

### 4.4 Field Test

The game was hosted on Unity Play through a WebGL adapter. The playtesting session was done for 30 minutes at a schedule agreed upon by the researchers and the tester. The study made use of Google Forms for questionnaires. Each tester was tasked to do the following: answer a pre-test questionnaire, play the game, answer a post-test questionnaire, and answer the game experience survey.

### 4.5 Game Results

The game was evaluated through three questionnaires given to the testers. These include the pre-test, and post-test questionnaires, and an adapted game experience survey that assesses game experience in players. These facets measure Immersion, Flow, Competence, Positive and Negative Affect, Tension, and Challenge [18]. The pre-test and post-test

questionnaires ask questions on the knowledge of the tester on aquaculture. The option for answering these questions uses the Likert scale with six (6) options to prevent testers from using neutral options. Answering 1 is equivalent to strongly disagree, while answering 6 is equivalent to strongly agree. Options in between are varying degrees of their opinion (i.e. 2 is disagree, 3 is slightly disagree, 4 is slightly agree, 5 is agree).

There was a total of 7 testers. Median was used as the measure of central tendency for the data set due to the ordinal nature of the choices supplied in the questionnaire.

**4.5.1 Pre-test Results.** This section deals with the tester's knowledge of the topics listed in the questionnaire before playing the game. Below is a table of results for the pre-test questionnaire from the 7 testers.

**Table 1: Pre-Test Results**

Tester	I have knowledge on what aquaculture is.	I am aware of the demand for aquatic resources in the Philippines	I have an idea of what the aquaculture process is.	I have knowledge on Tilapia culture	I have knowledge on how important aquaculture is to food and livelihood security.
1	1	4	3	1	3
2	5	3	3	3	5
3	2	3	3	2	4
4	4	5	5	5	4
5	2	4	2	2	2
6	5	1	4	2	3
7	4	5	3	4	4
Median	4	4	3	2	4

A median of 4 shows that the testers have a slight idea of what aquaculture is, are aware of the demand of aquatic resources in the Philippines and have knowledge of the importance of aquaculture toward food and livelihood security. A median of 2 for knowledge of Tilapia culture shows no knowledge of tilapia culture. A median of 3 shows the participants are not as sure of their idea of the aquaculture process.

The testers were asked to complete the sentence: "Aquaculture is important because..." Significant answers were from testers 4 and 7, who answered the scale with a median of 4 to 6. They emphasized there is a demand for aquaculture products and the provisions it gives to Filipinos. The rest of the testers show unsureness or outright no knowledge of aquaculture. Significantly, tester 1 wrote about not knowing what aquaculture is.

**4.5.2 Post-test Results.** This section deals with the tester's knowledge of the topics listed in the questionnaire after playing the game. Below is a table of results for the post-test questionnaire from the 7 testers.

**Table 2: Post-Test Results**

Tester	After playing the game, I have knowledge on what aquaculture is.	After playing the game, I am aware of the demand for aquatic resources in the Philippines.	After playing the game, I have an idea of what the aquaculture process is.	After playing the game, I have knowledge on Tilapia culture.	After playing the game, I have knowledge on how important aquaculture is to food and livelihood security.
1	5	4	5	6	4
2	5	5	5	4	5
3	4	4	4	4	4
4	5	6	6	6	3
5	3	2	3	4	2
6	6	4	5	5	4
7	5	3	5	6	5
Median	5	4	5	5	4

After playing the game, the testers agree that they have knowledge on aquaculture, on tilapia culture, and the aquaculture process with a median of 5 for all three statements. A median of 4 shows the participants have the awareness of the demand of aquatic resources in the Philippines and the knowledge of the importance of aquaculture to food and livelihood security.

The testers were then asked to answer questions on what about aquaculture and its process have they learned after playing the game. Each tester had different answers which they have recalled from playing the game. These concepts were knowledge of the different stages of the aquaculture process, segregation of male and female *O. niloticus*, and quality control.

**4.5.3 Significance of Results.** The pre-test and post-test results were compared using a paired t-test to see if there is a significant difference between the players' knowledge on the following: (1) aquaculture, (2) the demand of aquatic resources, (3) the aquaculture process, (4) tilapia culture, (5) importance of aquaculture to livelihood and food security before and after playing the game.

It has been observed that there is a significant difference between the testers' knowledge on aquaculture, the aquaculture process and tilapia culture with p-values of 0.0249, 0.0004, and 0.0046 respectively. Paired t-test results on the testers' knowledge were observed to be not significant with p-values of 0.5729 and 0.3559.

**4.5.4 Game Experience Questionnaire.** The Game Experience Questionnaire consists of seven components. The mean of each item in each component is taken as their scores in the scale to measure their experiences. These components with their corresponding items under them are the following: (1) Positive Effect, (2) Competence, (3) Sensory and Imaginative Immersion, (4) Flow, (5) Tension or Annoyance, (6) Negative Effect, and (7) Challenge. [18]

**Table 3: Results for Positive Effect**

Statement	Tester							Mean
	1	2	3	4	5	6	7	
I felt content	6	5	5	5	4	5	5	5.00
I thought it was fun	6	5	6	6	4	5	6	5.43
I felt happy	6	5	5	4	4	5	6	5.00
I felt good	6	5	5	5	5	5	4	5.00
I enjoyed it	6	5	6	5	5	5	6	5.43
<b>Total Mean</b>								<b>5.17</b>

**Table 4: Results for Competence**

Statement	Tester							Mean
	1	2	3	4	5	6	7	
I felt skillful	6	4	5	5	4	5	6	5.00
I was good at it	6	4	5	6	3	5	4	4.71
I felt successful	6	4	5	2	4	5	5	4.43
I was fast at reaching the game's targets	5	4	5	5	4	5	5	4.71
<b>Total Mean</b>								<b>4.71</b>

**Table 5: Results for Sensory and Imaginative Immersion**

Statement	Tester							Mean
	1	2	3	4	5	6	7	
I found it impressive	6	5	5	5	4	5	6	5.14
I felt rich in experience with the game	6	5	6	5	5	5	5	5.29
<b>Total Mean</b>								<b>5.21</b>

**Table 6: Results for Flow**

Statement	Tester							Mean
	1	2	3	4	5	6	7	
I was fully occupied with the game	6	5	6	5	5	6	5	5.43
I forgot everything around me	5	2	5	4	5	6	6	4.71
I lost track of time	1	3	4	5	4	5	5	3.86
I was deeply concentrated in the game	6	5	6	5	5	6	6	5.57
I lost connection with the outside world	1	2	4	2	4	5	1	2.71
<b>Total Mean</b>								<b>4.46</b>

**Table 7: Results for Tension or Annoyance**

Statement	Tester							Mean
	1	2	3	4	5	6	7	
I felt annoyed	1	4	2	4	3	2	1	2.43
I felt irritable	1	2	2	3	3	2	1	2.00
I felt frustrated	1	2	2	2	4	2	1	2.00
<b>Total Mean</b>								<b>2.14</b>

**Table 8: Results for Negative Effect**

Statement	Tester							Mean
	1	2	3	4	5	6	7	
It gave me a bad mood	1	2	1	2	2	2	1	1.57
I thought about other things	1	2	1	5	3	1	1	2.00
I felt bored	1	2	1	5	3	2	1	2.14
<b>Total Mean</b>								<b>1.90</b>

**Table 9: Results for Challenge**

Statement	Tester							Mean
	1	2	3	4	5	6	7	
I felt pressured	4	2	4	5	5	4	1	3.57
I felt challenged	6	5	5	5	5	5	5	5.14
I felt time pressure	1	3	4	6	5	4	1	3.43
I had to put a lot of effort into it	2	4	5	6	4	5	5	4.43
<b>Total Mean</b>								<b>4.14</b>

Testers agree on the positive effects of the game with a mean of 5.17. The testers also felt competent reflected on the mean of 4.71. The game was able to provide sensory and imaginative immersion with the mean of 5.21. The testers both disagree that the game induced tension or annoyance, and negative effects with means of 2.14 and 1.90 respectively. A slight state of flow was observed by the testers from an indication of a mean of 4.46. Lastly, the testers were slightly challenged by a mean of 4.14.

*4.5.5 Testers' Comments on the Game.* The testers mentioned that the gameplay, and aesthetics such as the design choice and background music of the game is enjoyable despite the amount of information the testers need to know at the beginning of the game. The visual cues on the icons help them navigate through the game. Two of the testers noted that there were bugs that needed to be fixed as they affected their performance while playing the game.

## 5 CONCLUSION

### 5.1 Effectivity on Learning

As shown on the pre-test and post-test results, there is an increase in median for knowledge on aquaculture, the aquaculture process, and tilapia culture. The median for knowledge of aquaculture increased by 1 after playing the game. The knowledge of aquaculture improved the most with its median improved by 3. This increase shows that the game has a potential of being able to teach aquaculture and its process, and tilapia culture.

There was no increase in median for the awareness of the demand for aquatic resources in the Philippines and knowledge on how important aquaculture is to food and livelihood security as such, the game did not provide much information on these topics compared to the former. It was brought to light by tester 4 that commented on a lack of story content of the game which would have made the game be more appealing to its audience.

### 5.2 Game Experience

Results from the Game Experience Questionnaire indicate an enjoyable game experience. Sensory and imaginative immersion, positive effects, flow were the highest categories among the players' experience. The testers were not affected by the negative experiences of the game and were not annoyed while playing the game indicated by low scores in the questionnaire.

With both results of negative effect and tension or annoyance scoring low on the game experience survey and the open-ended comments of the testers, it is concluded that the game provides an engaging and fun experience.

### 5.3 Translation of Mechanics

The game was able to depict the aquaculture process of *O. niloticus* through the following stages: (1) hatchery, (2) transportation, (3) grow-out and market selection, and (4) broodstock management. Points were given depending on the performance of the player in each of the stages.

General aspects of aquaculture such as waiting for the fish to grow, regularly feeding the fish, monitoring the fish, and moving the fish around the laboratory are present in all stages of the game. As opposed to the real-life aquaculture where aquaculturists wait for hours, days, weeks, or months – the average waiting time for these aspects are narrowed down to five to fifteen (5-15) seconds to follow the game time. This allows players to accomplish other tasks.

Repetitive actions such as harvesting, fish feeding or monitoring the fish are simplified into simply interacting with the game object since the top-down perspective limits the view of the player.

Certain actions are translated into a “hold button” game mechanic to indicate that the process requires energy expenditure and such.

Aspects of aquaculture that require a more detailed look are simplified into pop-up windows with a drag and drop feature to represent the aquaculturist's movement. All these game mechanics are reused for the entirety of the game.

**5.3.1 Hatchery.** In this stage, processes such as checking the quality of the fish eggs are translated into a minigame where the player drags and drops the division of good and bad eggs. This is a critical part of aquaculture since quality control is of utmost importance. Weighing and disinfecting the seedstock requires the player to be the one physically washing the batch, so a “hold button” mechanic was used. Aspects such as incubation and sex reversal stage use the waiting game mechanic mentioned from before to allow players to process more incoming batches of seedstock. Adding the sex reversal stage aids the player to know that tilapia cultivation is often monoculture to avoid overpopulation.

**5.3.2 Transportation.** The transport stage is divided into two parts: (1) loading, and (2) inside the vehicle. Filling in the PE bags with water uses the hold button mechanic to indicate that the player must be there in the station to monitor it, while adding oxygen uses the waiting time, giving the player more chances to move around the map.

For the second stage of the transport, the player focuses on monitoring the fish and the driver since there are a lot of factors that affect the fish when placed inside a moving vehicle. The developers wanted to give emphasis to the vulnerability of the fishes when being transported.

**5.3.3 Grow-out.** This stage is relatively simple and straightforward since the stage focuses on waiting for the fish to grow and harvesting them. The developers added the information wherein fishes must be conditioned before they can be placed into their grow-out tanks to, again, put emphasis on how fishes required maximum regulation even after transportation. In this stage, the player is constantly moving around the stage and choosing which fish batch goes to which tank, and which tank takes in which batch order. The act of harvesting the fish batch is translated into simply “logging in to the AquaFarm Ace” system to match the current ease of the game.

**5.3.4 Broodstock.** In this stage, the process of identifying the sex of the fish and separating male and female fish was translated into a minigame. The developers simplified the identification process by adding blue and pink visuals to allow the players to quickly finish the process. For the other parts of this stage, the player simply waits for the fish to mate and breed so that the player can process other broodstock batch.

## 5.4 Issues

Due The developers were able to complete all planned game features and mechanics from the initial project plan. However, upon releasing the beta version of the game for testing, there are still a couple of issues. According to the play testers, there are times when the players do not receive full points despite finishing a process properly. This is a rare occurrence that only a couple of the testers experienced. The researchers speculate that this is due to an error in its collision detection that destroys the wrong object at a wrong time. This is a major concern as the dynamics of the game highly relies on the points of the player. In addition to the problems of the collision detection, there are also a couple of instances where the process will stop despite being an 'on-going' process if the player decides to move out of the station. This is because the player destroys an object every time the player interacts with a station, and there are times when the detection will take in the wrong item thus destroying it.

## 5.5 Recommendations

Upon playing the game, most of the players initially had a hard time digesting the information that was shown on the screen. The players had a hard time retaining details even though they are able to view the manual any time during the game. Thus, the researchers deem it of utmost importance to improve the tutorial system into something more interactive and intuitive. A possible solution to this problem is to include a test run of a level prior to the start of the first level so that the players can navigate through the game and at the same time comprehend the process of aquaculture. Instead of simply having a tutorial manual UI, the researchers recommend integrating the actual tutorial to the game mechanics itself. This will help the players understand what they are doing when they are doing it.

Another recommendation is the addition of a well-defined storyline element. This will better immerse the player into the world of aquaculture as a story can highlight its demand and importance to societal issues, such as food or job security. A thorough research on the stories of the people working in aquaculture is suggested to add more depth and relevance to the game.

Since the game is simply in its early stages, it still has a lot of potential. Overall, the researchers recommend improving the communication of the game to its players. This does not simply involve the tutorials or the story-element, but also the rewards and consequences of the game. This would allow the players to feel the gravity of their actions each second. This can include adding additional points whenever players have a streak of perfectly processed fish which implies a deduction in their points whenever the player misses the internal cooldown of the station that needs attention. The inclusion of animations and background sound effects is also recommended to add a more immersive experience to the game.

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# WHIMCEE

## A Study on the Migration of WHIMC from Minecraft Java Edition to Education Edition

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### ABSTRACT

What-If Hypothetical Implementations in Minecraft (WHIMC) is an existing project and study that uses Minecraft as a platform for teaching and triggering interest in STEM to young students. It contains different Earth simulations and explores astronomic concepts related to exoplanets and celestial bodies. The research focuses on accomplishing a migration of the Minecraft worlds and functionalities of the WHIMC project that is based on Minecraft Java Edition into Minecraft Education Edition (MC:EE). More specifically, it entails migrating 3 of the Earth simulations called the “What If” worlds, which are “Earth without a Moon,” “Earth with a Colder Sun,” and “Earth with a 90 Degree Tilt.” Smaller versions of the What-if worlds were stitched onto one singular world file and had retrofitted functionalities using MC:EE’s in-game features and items. Then, user experience testing on the 3 What-If worlds was conducted which revealed the aspects of WHIMC on MC:EE that were well received and easily played and those that needed further improvement.

### CCS CONCEPTS

Applied computing → Computers in other domains → Personal computers and PC applications → Computer games

### KEYWORDS

Minecraft, Science Education, Educational Games, Multimedia Games, Computer Games, User Testing, Game Experience

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## 1 Introduction

### 1.1 Background of Minecraft

Minecraft is a video game that features sandbox-type gameplay [25]. Unlike a progression-type game wherein areas are unlocked sequentially, in a sandbox-type game, the player has full access to

the entire area or “world” right from the beginning of the game [24]. There are two main game modes in Minecraft: Survival and Creative. Survival mode’s main feature is to create objects and entities using blocks and materials that may be collected by players all over the world [25]. There are several types of blocks that have unique behaviors, and there are also specific tools that can be used to collect each of them. There are also hostile creatures and mobs that have block-type bodies, and players must defend themselves against these to survive. In Creative mode, players are invulnerable and do not have to worry about hostile creatures and mobs. Players do not have to collect materials and blocks and create objects and entities, as these can be acquired easily in Creative mode. As it is a sandbox-type game [24], there are minimal limitations as to what the player can do in the game, giving the player endless possibilities as to how they would approach the game.

### 1.2 Research Objectives

The goal of this paper is to accomplish a migration of the Minecraft worlds and functionalities of the WHIMC project that is based on Java Edition into Minecraft Education Edition (MC:EE). Minecraft is a well-known game, and the paper aims to better shed light on its educational capabilities in the country. This process includes identifying the parts of the migration process that will be seamless, be done with a translator, or be done manually. On top of the migration of the worlds and features, the researchers also intend to translate a positive satisfactory level of user experience into MC:EE, as one of the main goals of the WHIMC project is to make game-based learning more accessible and accepted.

### 1.3 Research Questions

In line with the research objectives, the paper attempts to answer the following questions:

- What would be the most efficient and effective way of migrating the WHIMC project to MC:EE?
- What are the core features and experiences of WHIMC that should and can be migrated into MC:EE?

- What kind of game experience will players have with WHIMC on MC:EE?

## 1.4 Scope and Limitations

The researchers aim to migrate the What-If Worlds of WHIMC Java Edition to Education Edition with its entities and functionalities included. However, a more specific scope that was agreed upon is migrating one functionality and making a singular, all-in-one world with all the exoplanets and what-if worlds stitched together, instead of a multiverse world. The reason for this is that there are certain limitations as to what functionalities Education Edition can have since it is not fully compatible with the exact plugins used in Java Edition (e.g., portals to different worlds cannot be done on Education Edition). Functionalities such as teleportation, quests, and observations will be done in a different manner on Education Edition, as it will be done through already existing and in-game features, as opposed to Java Edition which uses external plug-ins and modifications.

## 1.5 Significance of the Study

The researchers are concerned with addressing the need to migrate the WHIMC project from Java Edition to Education Edition since it contributes to the ongoing WHIMC collaboration between ALLS and UIUC. This research allows the WHIMC server to become more accessible, consequently making educational information and learning available to a wider scope of individuals. This is especially relevant now as the Philippines has one of the strictest lockdowns in the world due to the COVID-19 pandemic, where now more than ever education continues to find spaces where it can be continued given the current situation. With the need for educational institutions to shift to online learning, this paper aims to exhibit the need to make e-learning more engaging and progressive. As such, other researchers can also use this paper as a basis for future endeavors should more people, especially educators, wish to migrate Java Edition Minecraft servers to Education Edition.

## 2 Review of Related Literature

This section delves into the discussion of Minecraft as a whole and looks into its opportunities as a platform for learning. Minecraft being used as an educational tool in the WHIMC project will be introduced in a way that the game's endless possibilities are properly highlighted. As such, the use cases of Minecraft in both Java and Education Edition will be reviewed towards understanding the various relevant functionalities needed for comparison. This would then lead to the recognition of the benefits of using Minecraft: Education Edition in the scene of education among a general audience.

### 2.1 Minecraft as a Learning Platform

Minecraft is defined as a sandbox game that allows users to play the game in an open-world environment with endless possibilities. Users can approach the game in various ways and

enjoy the many features available in whatever way they please. This type of game is very popular among younger generations since it gives them a firm sense of control and creative freedom. Looking at the game in light of education, one can see how this type of gameplay encourages kids to think creatively and at the same time improve their cognitive skills. Because of the wide reach that this game offers, it would be beneficial to look at the perspective of the game as a bridge toward connecting the audience to innovative education in a relatable and engaging way.

There are also many ways to modify and restructure the base game of Minecraft through external plug-ins, resource packs, texture packs, and even hand-coded Java scripts. WHIMC is one example of a team of developers utilizing Minecraft's flexibility to influence children's development of STEM competencies. Several game modifications are made readily available for players and are widely used to improve one's gameplay experience.

The recognition of using games to easily entice kids to learn different topics has been in discussion for many years. Playing is by its very nature educational and incorporating relevant topics within play is incredibly beneficial for kids. With the upward growth of video games being one of the primary sources of enjoyment within kids today, it is only right that teachers now should look into the possibilities of utilizing certain games for the growth of young learners. Minecraft is arguably the most popular video game among children today which is why it is already widespread for the game to be recognized in the learning scene. In a 2012 article, Beasley wrote on her blog about the underrated benefits of Minecraft in the development of kids and the amount of learning that is involved within the game [2]. She explains her observations in a Minecraft activity that was conducted in school which showcased the collaboration, innovation, mathematical understanding, leadership, and peer-learning opportunities that were present through the gameplay.

Playing Minecraft alone is very educational with the large number of opportunities it brings for cognitive development. But the game itself can be catered further for learning, especially with the freedom of creation within the game, anyone is able to build and showcase different realities. From human anatomy to large historical landmarks, basically anything can be built for learners to view and interact within such an environment. Due to the ongoing rise in the appeal of using Minecraft as a tool for education, afterschool programs and clubs have formed over the years such as "Minecraft mania" [3] at the children's museum of Houston, and ThoughtSTEM [26], a network of afterschool Minecraft programs in California. These types of groups demonstrate how the game can bring together many people and form communities that collaborate in a fun and educational way.

One use case that displays Minecraft as a helpful learning platform is of Jeffrey Adams, a science teacher in Toronto who used Minecraft for a lesson to encourage his students to learn about sustainable planning [10]. The students were assigned various roles such as farmer, builder, or miner, and their task was to build their own model of a sustainable city. Adams was afterwards able to conduct interviews and surveys for his students regarding their Minecraft activity. The results of his study

suggested positive engagements with the given tasks. It was mentioned that 86% of the students preferred maintaining the use of games in the class. 80% of the students said that Minecraft allowed them to “be more creative and do things [they] couldn’t do before”.

Another qualitative study was conducted in 2014 by Anton Petrov which involved the experiences of multiple teachers who incorporated Minecraft within their lesson plans [20]. All teachers in the study had positive experiences with the engagement of the students through the game. The teachers shared similar thoughts wherein a large portion of the students’ interest was driven by the freedom that comes with the game. They themselves promoted this idea such that their lessons were given with a student-driven approach. With the different types of tasks and lessons that each teacher integrated within Minecraft, all followed a similar format that promoted innovative freedom as well as being a prosocial environment where the kids can interact and collaborate amongst each other.

## 2.2 Background on the WHIMC Project

The What-If Hypothetical Implementations in Minecraft (WHIMC) project was created by a team of University of Illinois Urbana-Champaign (UIUC) researchers and utilizes Minecraft, a popular video game platform, to engage adolescent students in learning Science, Technology, Engineering, and Math (STEM) [29]. It had its initial developments in 2017 and took fruition by 2019 and has since undergone numerous studies in relation to Minecraft as a mode of STEM education. The UIUC researchers behind the WHIMC project used data and learning analytics to identify the triggers found within WHIMC that invoke situational interest in STEM [6]. The concept of situational interest is the short-term desire to engage in specific content and learn more. The goal of the WHIMC project is to not only teach but also continuously foster and promote a learner’s excitement and interest towards STEM. As such, the project leverages situational interest to develop the opportunity of continuing such STEM interest of learners which can eventually lead to self-sustaining individual interest. WHIMC has since been launched and had playtests across different middle schools within the United States [6].

As the nature of Minecraft is a 3D-interactive sandbox game, WHIMC, hosted on a Minecraft Java Edition server, contains different kinds of explorable learning environments. These environments are framed by the science and theory of interest development and were designed after different kinds of astronomy and geology concepts to trigger interest in STEM [11]. On its most recent iteration it currently has a rocket launch base, moon base, space station hub, Earth simulations, and exoplanets. It also assigns players with quests and objectives with the goal to create scientific observations. One of its main features are the “What-If” Earth simulations which took inspiration from Neil Comins’ work and study as an astronomer. They simulate hypothetical situations such as “what if the Earth had no moon?” or “what if the Earth’s axis was rotated to a different degree?” that aim to stipulate curiosity on the scientific implications of an

altered Earth. With that, there are four different “What-If” worlds that simulate such altered conditions, which are “Earth without a Moon,” “Earth with a Colder Sun,” “Earth with a 90 Degree Tilt,” and “Earth as a Moon of a Gas Giant.” Each of these Earth simulations have their own unique playthroughs and functionalities that learners can explore.

The first What-If world is Earth without a Moon [29], which simulates how life on Earth would be if it were to not have a moon. It demonstrates how the absence of the moon meant that there would be no seasons, since the Earth’s rotational axis would become perpendicular to the plane of the orbit around the Sun. This would result in the hours of the day being three to four times shorter, which would change weather and wind patterns. In short, flora and fauna evolve much differently to thrive under these new conditions. For instance, the Earth without a Moon world simulates how the presence of high wind speeds cause trees to grow in abnormal shapes and nighttime would be much darker since only starlight would be present. The second What-If world is Tilted Earth [29], which shows what would happen if the Earth were tilted at an extreme axis of 90° as compared to 23.5° tilt. The conservation of angular momentum dictates that Earth being tilted at 90° would mean that its rotational axis will always point in the same direction as Earth orbits the Sun. As a result, one time each year the North Pole is pointing toward the Sun and six months later it is pointing directly away from the Sun. Tilted Earth demonstrates this new change of seasons and day-night cycles. The third What-If world is Colder Sun [29], which simulates what Earth would be like if the sun’s temperature were cooler. The distance from which the Earth orbits the sun is what makes life on Earth possible and sustainable, for instance the surface temperature of Earth enables water to retain a liquid state consistently. What Colder Sun aims to simulate is how life would be if Earth were outside the sun’s habitable zone and how such conditions would change. As a result, Earth with a Colder Sun has two drastically different North and South regions, where the North region is hot with very high temperatures and full of orange sand, and the South region has extreme cold weather and low temperatures, being filled with snow. The fourth What-If world is Earth as a Moon [29], and in this new world, the roles of the Earth and Moon have been switched such that the Earth is a moon of a larger world. This What-If world demonstrates what life would be like on an Earth-like world called Mynoa as it orbits a much larger planet named Tyran.

In terms of using data and learning analytics, the WHIMC server makes use of external plug-ins and specially coded plug-ins that are used to extrapolate data from the learner’s game play on WHIMC. Going back to the results of WHIMC, it is currently going through more improvements and additional features. However, the studies and analytics conducted on WHIMC based on its previous launches in middle schools and recreational centers display how WHIMC was able to achieve its goal of triggering STEM interest and is since being developed further [30]. It has since been tested and had data collection sites at the UIUC Fab Lab, Children’s Museum of Indianapolis, Urbana Neighborhood Connections Center (UNCC), and Next Generation

School. The WHIMC teams collected data through user surveys (pre-experiment and post-experiment), conducting 1-on-1 and pair interviews, fieldnotes, and further statistical analysis. The researchers would teach the students on how to navigate through WHIMC and observe how they are able to complete the quests and objectives of the game. Then, data is extrapolated from each player's unique gameplay and is processed to determine how they were able to interact with the game. Examples of such information gathered were as analyzing the measurements and observations the students noted in-game, how much time a student spent exploring certain portions, and mapping out which areas of the world were explored the most.

In summary, WHIMC is founded on the core principles of how game engines can be utilized to encourage students to engage with STEM concepts and how What-If questions are a powerful tool in triggering interest development [28]. Its research focuses on measuring changes in interest and knowledge as learners, specifically those who have used WHIMC, engage with the in-game worlds and its activities. It then extrapolated different learner observations such patterns of engagement and analyzed the way interest emerges from a combination of "freedom to explore, working with peers, and interaction with experts" [11].

### 2.3 Benefits to Education Edition

Minecraft: Education Edition is a newer version of Minecraft that Microsoft developed because of their growing interest in using Minecraft for education early in its acquisition of the game, they reached out to educators to learn more about how Minecraft: Java Edition was used in a classroom setting to get a better understanding of how to develop Education Edition that was more suited for a classroom environment [9]. The flexibility and largely visual user interface of MC:EE give opportunities for the educators to use it in any language.

Minecraft was initially released as a game with no fixed instructions on how to play the game, and it was expected for players to learn the game through their own explorations and experimentations with their own imaginations in mind [9]. With the development of MC:EE, tutorials were largely implemented to make it easier for users to get a good understanding of the basics of the game, which is incorporated into the game's tutorial map [9]. In the game tutorial map, educators are required to play to learn all the basic game functions. On top of that, several other maps and resources can be downloaded from the MC:EE website, which can help further generate potential ideas for classroom infrastructure.

MC:EE is more accessible, in that it can be downloaded for free by any emails, usually school emails, that are tied to a Microsoft 365 account. It can also be played offline in single-player mode or multiplayer mode on Mac OS or Windows 10, depending on the infrastructure of the classroom, and a software download is required for installation of the game on desktop computers. Once the software has been downloaded, all necessary files for the game are automatically installed into the computer. The game will also automatically update to newer versions as they are released.

MC:EE also has a multitude of features which make it easier for educators and students to utilize the basic aspects of the game [9]. Despite losing the flexibility of the original Minecraft, it offers more structured features and educator tools baked directly into it. The older server commands and operations of the original Minecraft are restructured for MC:EE in order to give it a newer graphical user interface through the game's Classroom Mode, which provides teachers with a server interface where they can modify different aspects of the game such as the weather to control functions like how often it can rain, chat box functions to control who can chat and what they can send, player health to control their vulnerabilities to other elements, and player-fighting to control who players can deal damage to or what they world elements they are allowed to destroy [9].

MC:EE has been used widely for educational purposes, in a study entitled "Using Minecraft Education Edition to Teach Cybersecurity Self-Defense," it has been used for the instruction of Cybersecurity Self-Defense skills to K5-8 students [7]. They created an ancient ruins city which students then navigate through and encounter various Non-Player Characters (NPCs) to progress through the storyline. These NPCs are interactable and they ask the students questions pertaining to Cyber Security to educate the students on online safety. In another study entitled "SEL & MEE: Teaching Students SEL Skills Through Minecraft: Education Edition," they also used MC:EE to help develop students' Social and Emotional Learning (SEL) [22]. Research has shown that students who were taught SEL tend to have a decrease in symptoms of delinquent behavior and depression. In their project, they teach students five core competencies of SEL using five separate worlds that are easy to navigate. Each of the worlds utilize the Journal item, which contains at least five questions pertaining to activities and encounters within each world, and the Quests feature which give students specific tasks that are geared towards increasing the understanding of the SEL core competencies. On the MC:EE website itself, they have several lesson plans which may be downloaded and modified by the users. An example is the Extinction! Safari lesson plan wherein players utilize Minecart and Railings items to explore the world which is filled with extinct species and are made to investigate the causes and the possible solutions to stop the biodiversity crisis [15]. On the website, users are also provided with the Minecraft world file, a Biodiversity toolkit which provides the students with an understanding of the importance of nature and how all living things are connected, a video introduction to the lesson by a professor, and a teacher guide which can assist the educator with all the pertinent information regarding the extinct species that are featured in the lesson.

Minecraft: Java Edition has the flexibility and variability needed for the implementation of Minecraft worlds due to having more resources and available research materials because of its earlier release. However, it tends to become more difficult and time-consuming overtime in terms of optimizing and creating a learning environment for educational purposes and instruction of material. Hence, Minecraft: Education Edition can be more optimal for conducting a learning environment, as its built-in

features and tutorials, and more user-friendly interface makes it easier to set up the Minecraft world in relation to being tailor fitted to educational needs.

## 2.4 A Look into Minecraft Java and Minecraft Education Edition

The design basis of Minecraft Java Edition and Education Edition are inherently different, with Java Edition having more flexibility and a larger library as compared to Education Edition, which is what allows the latter to have a vast variety of in-game modifications. While this is highly beneficial for conducting unique uses in education and research, a study by Nebel et. al [17] states how Minecraft has a high learning curve and can pose gameplay and technical challenges amongst teachers and players.

As mentioned earlier, Mojang, the creators of Minecraft, released the game with no set instructions [9]. This has caused limitations on those who are trying to implement and use Minecraft as a learning tool. Despite much optimism and good feedback on Minecraft used for education, this does not necessarily equate to it being an optimal tool and solution for all types of learning scenarios.

Additionally, for the students who would be using Minecraft, there could potentially be two different kinds, which are those with more exposure and experience in Minecraft and those without. Experienced players could have pre-existing ideas of a learning environment, create and test less extensive new hypotheses or have less organic learning simulations, or dominate in what were supposed to be collaborative scenarios [17]. Those with lesser or without prior knowledge on Minecraft would have to deal with learning and adapting to all the different kinds of mechanics of the game in addition to the specific learning tasks and objectives given to them [17]. As a result, teachers and researchers must further develop the ways in which Minecraft is used in education and focus on making world building content that is easily shared and accessible, collaboratively created, and modified without systematic restrictions or high technical demand [17].

This is where the benefits of Education Edition come in. As Minecraft Education Edition was developed much later, Mojang has better catered it to an educational setting. As such, MC:EE has increased game tutorials and released better documentation, which can be downloaded directly from the MC:EE website [9]. The in-game tutorial supports the learning of educators and better equips them with game functions. MC:EE reduces its flexibility as compared to that of the original Minecraft, however it was a stylistic choice to provide educators with much more direct and simplified tools that are implemented directly into the game with the creation of Classroom Mode [9]. Education Edition is also designed to have a much better learner fit approach by better addressing the problems of students being unmotivated to learn the materials or alienated from lack of structure. By providing already created classroom resources such as pre-built worlds along with their respective guidelines, lesson plans, solutions, and walkthrough videos, students and teachers can better understand and follow the game while also capitalizing on Minecraft's open-

ended nature to create better collaboration and context-based learning [9].

Minecraft: Java Edition and Minecraft: Education Edition have both been used for learning and instruction, but they have features that make them different from each other. For example, worlds from Java Edition cannot be used in Education Edition and vice versa. A feature called NPCs, which are characters in-game which help make for a more interactive gameplay, are already integrated into Minecraft: Education Edition upon installation [7]. They can be easily added to the world by typing the command `"/summon npc"` into the chat box. They also have characteristics which can easily be edited in game, like Name that allows the user to modify the display name of NPCs, Dialog which lets the player assign a set dialog for NPCs, Appearance which allows the user to change the skin of the NPC, URL which allows the user to add a hyperlink button to redirect other users to an external website, and a Command feature which lets the user add one or more executable commands to the NPC such as teleportation to a specific location or giving a player an item such as a Quest Journal item which allows players to accept quests [7].

However, for Minecraft: Java Edition, an external modification (mod) such as Custom NPCs must first be downloaded and installed to add NPCs to the Minecraft worlds [19]. To add an NPC, the user must first craft an in-game item called NPC wand which they can use to either spawn new NPCs or clone existing ones. Java Edition NPCs have a lot more customization options than the Education Edition one, they have modifiable characteristics that the latter doesn't have like Visibility which determines if the NPC is visible to players or not, Texture wherein the user can upload their own .png files to make a more unique and custom NPC look, Model which determines the base model of the NPC, Immunity which determines from which worldly elements the NPC is immune from (e.g. player punches, lava, fall damage), Role which determines the actions and behavior of the NPC (e.g. (1) A trader who can exchange items with players, (2) A zombie who will attack players), Aggressiveness which determines the conditions for which an NPC is to attack a player (e.g. A spider which attacks players if they are one meter away from them [4]). After creating the NPCs, quests can then be implemented, and the user can control what the NPC wants the player to do or find and set the rewards upon the completion of the task.

Both Minecraft: Java Edition and Minecraft: Education Edition have their respective pros and cons. What is important is that when deciding which platform to use over the other, whether it be for educational purposes and research purposes, is to take into consideration how exactly these factors would directly affect their main stakeholders, the teachers (facilitators) and the students (the learners and players).

## 3 Methodology

This section details the methods done in terms of the migration of WHIMC Java into MC:EE. The methodology is divided into 5 stages. The first stage is the defining stage, which mainly focuses

on the exploration of the original WHIMC world, specifically the What-If worlds to find out the key features that can and cannot be migrated into MC:EE. The second stage is the planning stage which delves into the creation of the migration checklist and listing down each of the sections that need to be migrated and ranking them in order of importance and difficulty. The third stage is the migration stage that discusses the steps in which the What-If worlds were stitched and consolidated into one singular game file for its migration into MC:EE. The fourth stage is the gameplay stage, which is how the core features such as quests and observations will be brought to Education Edition. Lastly, the fifth stage discusses the protocols and measures taken for the user experience testing. The goal of the testing is to discover the participants' game experiences and assess the aspects of the game that work well and what need to be improved.

### 3.1 Defining Stage

The initial process for the development of WHIMC in MC:EE, or also known as WHIMCEE, was to define and map out everything that needed to be migrated from the original WHIMC Java server. The researchers had to explore each of the What-If worlds on the WHIMC server firsthand to get a good idea of what features are important and crucial to the definition of each respective world, while also understanding the perspective of a general user through interaction. The exploration begins in the main hub, which then leads to the rocket launch base where all the What-If worlds are made available to jump into. For this specific scope, only 3 What-If worlds are available for exploration and migration, which are Earth without a Moon (No Moon), Earth with a Colder Sun (Colder Sun), and Earth with a 90-degree Tilt (Tilted Earth). As each What-If world was explored, the different key features available were noted down which include the NPCs, quests, and portals. Along with this, it was also necessary to observe how the quests affected the progress of a user and which of the succeeding quests and worlds were made accessible depending on the user's progress.

The What-If worlds had a similar sense of how the quests and NPCs were distributed in terms of their format and progression. The first What-If world on the agenda was Earth without a Moon which had a building that consisted of two NPCs. The first NPC unlocks the observation quest and explains how it is done. The next NPC in the building unlocks the accessibility to the next world scenario. Once the given quests on Earth without a Moon are done, the user is then able to move on to Earth with a Colder Sun. This world comprises three different scenarios, the habitable strip, hot side, and cold side, which are all made accessible through portals. An NPC is seen in the habitable strip which unlocks the observation quest where the user is tasked to observe all three areas of the world. When the user reaches the cold side, an underground base is met with another NPC that unlocks the next available world scenario.

Identical to the previous world, Earth with a 90-degree Tilt is made available once the quests on Earth with a Colder Sun are accomplished. This world is also like the previous world wherein it has three different scenarios that are all accessible with portals.

The user is similarly greeted in the world by an NPC that unlocks the final quest to observe the three given areas. The portals are described as time machines which lead the user to the time spans of 6 months in the future, 3 more months in the future, and finally back to the origin. As soon as all the time spans are observed, the user is granted an achievement which says that all available What-If worlds have been successfully observed.

Once all the important features and core experiences were noted down, the researchers then proceeded to assess and list down how each functionality can be successfully migrated to MC:EE. The NPCs can be brought simply using the NPCs that are available in MC:EE itself. Observations and quests can be made using a combination of Photographs, Journals, Slates and Command Blocks, along with the necessary NPCs that grant such quests. Finally, teleportation can be smoothly executed with Command Blocks, as well as NPCs with an encoded teleportation script.

### 3.2 Planning Stage

By completing the defining stage, the researchers then delved into the planning phase based on what was encountered during the exploration of the What-if Worlds. The first part was the creation of a migration checklist that entails the order of migrating each What-If world and to rank them according to their respective predicted difficulty in migration.

From easiest to hardest, the first What-If world to migrate was Earth with No Moon, or the No Moon world. As compared to the other worlds, there is only one "instance" (world file) of No Moon along with only having a fixed night-time schedule. Only having one world file meant that all its required quests can be completed in one location. This would be the first What-If world to migrate.

The next What-If world to migrate would be Earth with a 90 Degree Tilt, or Tilted Earth. This was the second in terms of difficulty to migrate, as there are three different world instances, which are the Frozen world, Jungle world, and Melting world. Tilted Earth's Frozen world was the easiest to migrate, as there is smaller variety in terms of blocks, smaller number of blocks than others, and has no water involved unlike the other worlds. Tilted Earth's Melting world is second in terms of difficulty as it has more variety in terms of blocks than Frozen but less than Jungle, and the world has water, which is difficult to work with due to its unpredictable nature and movement in-game. The Jungle world was the hardest out of all Tilted Earth instances, as it has more blocks than Melting and Frozen due to having several tall trees, more variety in terms of blocks, and the world has water, which is difficult to work with.

Lastly, Colder Sun was deemed the hardest in terms of difficulty to migrate, as there are three world instances for the world, which are the North world, South world, and Habitable world. It was even proven more difficult than the rest due to the size of the schematic files (the world files) being bigger due to them having more blocks than other worlds. Both the Colder Sun's North and South worlds had tall and mountainous terrain, which meant more blocks had to be migrated, resulting in a larger and heavier schematic file size. Colder Sun's Habitable world,

unlike the North and South instances, mostly had flat surfaces and did not have tall and mountainous terrain. However, the world itself is much larger and wider in terms of blocks used. This instance had the most variety out of all What-if worlds, as it included 6 different biomes within it, which were the Desert biome, Snow biome, Taiga biome, Savannah biome, Jungle biome, and Forest biome. Biomes had to be changed for each part of the world, as they are not automatically changed upon migration.

Being that there were several worlds to migrate, the researchers found that it was best to split the worlds between the two groups. The division became 3 What-If worlds for this research group and 3 Exoplanets for the other group. Given that there is no Portals and Multiverse plugin for Minecraft: Education Edition, there is no way to recreate the feature of WHIMC's Java Edition to travel between different world files. As an alternative, the researchers proposed to move all worlds to one master world file.

### 3.3 Migration Stage

As this is a joint effort between two thesis groups, migration was conducted on a multiplayer server, so that the changes that one person makes would reflect across all the researcher's local computers. Minecraft multiplayer mode needs a host for the server. Most Minecraft hosting services tend to be expensive, but the researchers found a free Minecraft hosting service named Aternos, which the researchers decided to use for this project. Being that Aternos is a free Minecraft hosting service, it has its downsides. For instance, the host must waitlist if they want to set the server status to online, which takes approximately 5 minutes every time. To use Aternos, one person creates an account on their website, and they will be asked to choose the type of Minecraft server that they want to use. There are two Minecraft plugins needed to efficiently stitch the worlds together, which are WorldEdit and Forge which can be accessed by using a Bukkit server. WorldEdit and Forge enables the simultaneous manipulation of blocks on a wide scale, which is a key aspect in maintaining the original structure and design of the landscapes of the What-If worlds.

The What-If world stitching was done on Minecraft: Java Edition first, as this version of Minecraft contains plugins which will help make it easier and more efficient to move all WHIMC worlds to one world file. To begin the stitching process, the WorldEdit plugin was used to save each of the WHIMC worlds into .schematic files. After saving all the worlds, they were pasted on the master Minecraft world file and were separated from each other.

After stitching the different worlds together, a downloadable software named MCCToolChest was used to convert the Java world into a Bedrock (Education Edition) world. Being that the two editions of Minecraft have a difference in terms of blocks and items, some blocks which were present on the Java edition but absent in the Education edition were replaced by other blocks.

### 3.4 Gameplay Stage

The researchers noted down the core gameplay of the original WHIMC, which tasked players to complete 3 missions. These missions combine quests and observations together. There are:

- Mission 1: Visit Unaltered Earth and No Moon
- Mission 2: Visit Colder Sun
- Mission 3: Visit Tilted Earth

That is because the quest for a What-If world is to create and complete at least one (1) observation on the What-If world. Directly taken from the original WHIMC, there are 5 kinds of observations, which are "descriptive," "comparative," "inference," "ask a question," and "uncategorized" that can be made in the What-If worlds using observation templates. Depending on the What-If world, these templates have different items and suggestions for players to use as a guide in creating observations. It was seen that if a player creates at least one observation, they have successfully completed the quest of that respective What-If world scenario.

### 3.5 User Testing Stage

As the complete migration of the What-If worlds into MC:EE has been completed, the last stage is to conduct user testing. The purpose is to test the playability of the What-if worlds and to discover the participants' game experiences. The researchers have tested how much a player would successfully complete given tasks and objectives as they explore the different What-If worlds and their scenarios. The results of the test and feedback of the participants were used to find out which features have relatively high success rates and how to further improve on the aspects of the worlds that have lower success rates.

The target audience for the user testing were college students based in the Philippines of ages 18 and above. They are required to have the necessary equipment needed for the study such as a laptop or personal computer able to run Minecraft Education Edition, stable internet connection, and a working computer mouse. Prior experience with Minecraft is not needed for this user experience test as the WHIMCEE gameplay is designed for general use. As each participant will only test 1 What-If world, making it 5 participants per What-If world, a total 15 participants are needed for the user testing.

To gather the participants for the test, an open invitation was released via Facebook inviting college students to participate in the study. Once the researchers selected and confirmed the 15 participants, they were sent an instruction kit containing instructions on how to prepare for the testing proper. They were instructed to download MC:EE, the MC:EE file containing the WHIMCEE instance, and the confidential log-in details that will be used to access MC:EE.

Each user testing session was conducted for a total of 60 minutes. The testers were provided with a brief background regarding the original WHIMC as well as the context of WHIMCEE and the test proper. They were presented the goals and purpose of the user testing along with final reminders for the session.

In the game proper, participants shared their screen to be effectively observed and guided by the researchers. As the participants entered the WHIMCEE world, they started at the

space station lobby which served as the hub for all What-if Worlds. The users were briefed about the guides and instructions placed throughout the game, which meant that the observers only reached out for assistance when necessary. Given this, the duties of the researchers of the group were to assess how much of the tasks and quests indicated for a specific What-If world a player completed in 30 minutes. More specifically, the success level of the tasks signifies how much they can accomplish the key WHIMCEE game play features of game traversal (teleportation), interaction (bots, instructional NPCs and signages), and exploration and observation (tools and measurements).

For each task, there are 4 success ratings, which are succeeded, partially succeeded, succeeded with help, and not succeeded. As the player carries out their tasks, the researchers track the corresponding success ratings the participant can achieve for each respective task. After the participants completed the game session and all the tasks needed in the What-If world, they answered an in-game and post-game questionnaire patterned after the game experience questionnaire (GEQ) of IJsselsteijn, de Kort, and Poels' study [8]. The GEQ was created for the Fun of Gaming (FUGA) project which consists of different methods and measures of analyzing humans' digital game experience and enjoyment [8]. This provided additional insights and enabled the researchers to assess the game experiences of the participants during and after the game session.

## 4 Results

### 4.1 Overall Migration of WHIMC to MC:EE

In terms of the landscape design, only chosen portions of each of the original What-If worlds were migrated into MC:EE as size control was needed for stitching them onto one file. This was done due to the feature constraints of the current versions of MC:EE, such as the absence of the Multiverse plugin in Java Edition which allows the connection between different world files. Given this scenario, the researchers remedied this by stitching the different worlds together all in one file. The first step was to create a schematic of the worlds and each of their scenarios. In the original version, worlds could go up to 1000x1000 blocks big, and given that there are 7 What-If world scenarios it could result in a large file size. So instead of including the full worlds, a 200x200 block schematic was made from the original version for each of the worlds and scenarios: Earth with No Moon, Earth with Colder Sun (Habitable strip, West, and East), Tilted Earth (Main, 6 months into the future, 3 months into the future). This resulted in a total of 7 What-If World scenarios being stitched and migrated.

Then, to compensate for WHIMC Java's Multiverse plugin that creates the feeling of teleporting into different worlds, each scenario was placed in faraway coordinates so that players will not be able to see the other stitched worlds from the ends of each of the worlds. To simulate the experience of being in a completely solo world, its respective terrains were extended. For Tilted Earth, the concept is that it is a remote island in the middle of the ocean, meaning that the water of the world should extend beyond the

player's sight to create the "in the middle of the ocean" effect. Hence, its terrain extension is done with water, ice and more land depending on the scenario. For Colder Sun, its concept had three different scenarios within it, hence it was extended with either orange sand mountains and snow and ice mountains. For No Moon, it has a 200x70x200 block wall named "skyblock" to simulate the consistent nighttime pattern, so it did not need further terrain extension.

Due to migrating smaller portions of each world, cosmetic modifications were done in MC:EE to ensure that all their important features, such as coral reefs, mountains (dirt, snow, and sand), caves, forests, grass, and flora were maintained properly. Invisible boundaries were added as well to restrict players from exploring beyond a certain point in each of the What-If worlds. For the functionality of WHIMC on MC:EE, it was ensured that entities and structures found in the original What-If worlds were also migrated. All the What-If worlds and their respective scenarios retained their rocket ships, greenhouse buildings and bunkers.

Furthermore, MC:EE has built-in NPCs and this was used as the alternative for the features of WHIMC Java Edition such as the Citizens, Portals, and Quests plugins because they have programmable command buttons that users can interact with. This meant that apart from migrating the NPCs found in the original WHIMC, new NPC bots and characters were added. For instance, the Teleportation NPC (TeleBot) was given a command button that allows players to easily teleport to a specific coordinate of a What-If world or area. Also, the NPC-specific command blocks were programmed to give players 3 in-game items which are the Book and Quill, Camera and Portfolio as an alternative to the observation tools of WHIMC Java Edition. With these items, players write their observations on the different worlds and can later be converted into a PDF file which the players and researchers may use as a future reference. The observation templates were recreated on MC:EE using Written Books (signed version of the Book and Quill). These NPCs worked alongside a new structure called the Measurement Building, which had a Measurement NPC (MeasureBot) that displays a dialogue box that players can read off from which contains the specific measurements of the scenario they are in and to aid in the observation making.

### 4.2 Gameplay of WHIMCEE

Given that WHIMC on MC:EE, coined as WHIMCEE, would make use of its unique in-game items for features such as observations and teleportation, a newly designed gameplay was created. The start of the gameplay begins at the Space Station lobby wherein players will be able to find different NPCs which will give them more information about the station, and the different TeleBots which will give them the option to travel to the different What-If worlds. Once a player has arrived at a What-If world, players will be greeted by a TeleBot on the left which will give them the option to travel back to the station, and an Information NPC (InfoBot) on the right which will give them a bit of background on the What-If world that they are currently on.

Afterwards, when players step down from the rocket, they will see a board that provides a list of tasks to accomplish, which will serve as their quest for the world. Following the quest will be crucial to the gameplay of the world, as some important features will not be accessible to the player until they have finished a specific part of the quest. The first part of the quest will entail players interacting with NPCs to obtain their observation tools: Book and Quill, Camera, Portfolio, and Observation Template Book. Once they have their tools, the players will have to complete the Diamond Keycard quest, where they will look for the NPC that has the Diamond item, which can be used as a keycard to gain access to the Measurement building where the MeasureBot NPC is situated, containing the different measurements of the What-If world.

Next, the players will create observations by writing them down in their Book and Quill item and by taking pictures of the different interesting sights with the use of their Camera and Portfolio items. Once they have finished making observations, they will sign their Book and Quill and Portfolio items and export them as PDF files, so that players can have a copy of their observations after going through the world. Then, after signing their books and finishing their quest, the player will travel to the next What-If scenario (e.g. From Tilted Earth Main, travel to Tilted Earth After 6 Months) and accomplish the following quests, or travel back to the space station to explore the other What-if worlds.

### 4.3 User Testing

A total of 15 participants took part in the user testing, with 5 participants assigned to each What-If world. As the participants explored the respective world, the researchers recorded the capacity in which they were able to complete the tasks in the gameplay. The tasks were also categorized into 3 of WHIMCEE's main player features and game abilities, which are journeying (traversing through the game), delving into in-game interactions, and observation making. Overall, the tasks were signified by a 4-point scale with the items "Succeeded" for 4 points, "Succeeded with help" for 3 points, "Partially succeeded" for 2 points, and "Not succeeded" for 1 point. The success rate for each task and their respective categories were signified by its average score on the 4-point scale.

After the participants finished the game play, they were given a game experience questionnaire (GEQ) [8] to assess their in-game and post-game experience with WHIMCEE. The statements to be answered assess the player's thoughts and emotions during and after the game play session. For each statement in the GEQ, players answered their level of agreement with a 5-point scale with "Extremely" for 5 points, "Fairly" for 4 points, "Moderately" for 3 points, "Slightly" for 2 points, and "Not at all" for 1 point. All the What-If worlds' in-game and post-game results were cumulated and the average rating per statement and their respective categories was then computed.

#### 4.3.1 Participant Prior Minecraft Experience

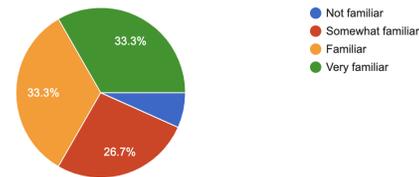


Figure 1: Familiarity with Minecraft

The demographic of the participants were all Filipino college students of ages 18 and above. The figure indicates their familiarity with Minecraft. Overall, there was a fair balance of participants who were very familiar and had good command of their knowledge of Minecraft with those who were only familiar and slightly familiar with the controls of Minecraft.

#### 4.3.2 Colder Sun Results

Table 1: Average Score for Colder Sun Tasks

Task	Average Score
(1): In the space station lobby, go to the Colder Sun and teleport	3.60
(2): Enter the Colder Sun habitable strip and speak to the InfoBot	4.00
(3): Exit the rocket and read the instructions on the board	3.80
(4): Look for Jorge in the dessert	3.40
(5): Speak to Jorge and receive your observation tools and observation template journal	4.00
(6): Explore the world and make observations (using observation templates) with the Book and Quill, camera, and portfolio	3.40
(7): Go up the stairs to access the Colder Sun bridge	3.80
(8): Depending on the side of the bridge (either right or left), travel (teleport) either East or West	3.80
(9): Arrive at West Colder Sun's rocket and speak to the InfoBot	4.00
(10): Head down the rocket and read the instructions on the board	4.00
(11): Look for Josephina by the solar panels and get further instructions	4.00
(12): Head to the underground bunker first level and look for Damien to receive observation tools	4.00
(13): Head to the second level (lowest level) and look for Pierre and Anita	4.00
(14): Talk to Pierre and Anita and learn more about West Colder Sun	4.00

(15): Get the observation template journal and the diamond keycard from Anita	3.40
(16): Head to the measurement building and unlock it with the diamond	3.20
(17): List down the measurements	3.20
(18): Explore the world and make observations (using observation templates) with the Book and Quill, camera, and portfolio	4.00
(19): After making observations, teleport back to the bridge in the habitable strip of Colder Sun	3.80
(20): Arrive at East Colder Sun's rocket and speak to the InfoBot	4.00
(21): Head down the rocket and read the instructions on the board	4.00
(22): Look for Jack and Vera at the underground bunker	4.00
(23): Talk to Jack and take your observation tools and observation templates journal	4.00
(24): Talk to Vera and take the diamond keycard	3.80
(25): Head to the measurement building and unlock it with the diamond	3.60
(26): List down the measurements	3.40
(27): Explore the world and make observations (using observation templates) with the Book and Quill, camera, and portfolio	4.00
(28): After making observations, teleport back to the bridge in the habitable strip of Colder Sun	3.60

Table 2: Average Score for Categorized Colder Sun Tasks

Task Number	Category	Average Score
1, 7, 8, 19, 28	Teleportation and Journeying	3.76
2, 3, 4, 5, 9, 10, 11, 13, 14, 20, 21, 22	Interactions (bots, instructional NPCs and signages)	3.93
6, 12, 15, 16, 17, 18, 23, 24, 25, 26, 27	Exploration and Observation (tools and measurements)	3.64

Overall, the players were able to accomplish most of the tasks when given enough time and opportunity to explore Colder Sun. The only problems that occurred were during the observations and listing down of measurements. Some players end up forgetting to observe their surroundings and require a reminder from the researcher. Others got too excited with exploring and proceeded further out in the world while forgetting to retrieve their observation tools from the first NPC. Players with less familiarity with Minecraft also had trouble with accessing the

measurements within the observation tower. It is also important to note that the players have trouble knowing when they have succeeded with their goals or when they are done exploring the world.

#### 4.3.3 Tilted Earth Results

Table 3: Average Score for Tilted Earth Tasks

Task	Average Score
(1): From the space station lobby, go to the Tilted Earth room and teleport	4.00
(2): Arrive at Tilted Earth and speak to infobot inside the rocket	2.80
(3): Exit the rocket and read the instructions on the board	4.00
(4): Talk to Clara and follow her instructions	4.00
(5): Head to the base up in the hills and look for Jake	4.00
(6): Talk to Jake and take the observation tools and observations template	3.20
(7): Talk to Lisa and take diamond key card	3.80
(8): Head to the measurement building and unlock it with the diamond keycard	4.00
(9): List down Tilted Earth Main's measurements	2.40
(10): Explore the world and make observations (using observation templates) with the Book and Quill, camera, and portfolio	4.00
(11): After writing down observations, travel (teleport) 6 months into the future	3.00
(12): Arrive at 6 months into the future scenario and speak to the InfoBot	1.60
(13): Exit the rocket and read the instructions on the board	4.00
(14): Head to the base building and look for the NPCs to speak to	3.80
(15): Enter the base building and speak to Niki to get your observation tools and observation templates	3.60
(16): Talk to Wendy and take diamond keycard	4.00
(17): Head to the measurement building and unlock it with the diamond keycard	4.00
(18): List down the measurements	3.20
(19): Explore the world and make observations (using observation templates) with the Book and Quill, camera, and portfolio	4.00
(20): After writing down observations, travel (teleport) 3 months further into the future	3.80
(21): Arrive at the new scenario of 6 months	1.60

into the future and speak to / greet the InfoBot		(4): Head to the greenhouse and meet the different NPCs and read further instructions on the signages available	4.00
(22): Exit the rocket and read the instructions on the board	4.00	(5): Talk to Carl and take the observation tools and the observation template journal	3.60
(23): Head to the base building and look for the NPCs to speak to	4.00	(6): Talk to Tanya and take diamond key card	3.80
(24): Enter the base building and speak to Irene to get your observation tools and observation templates	4.00	(7): Talk to the security guard and unlock the measurement building	3.60
(25): Talk to Naevis and take the diamond keycard	4.00	(8): List down the measurements	3.20
(26): Head to the measurement building and unlock it with the diamond keycard	4.00	(9): Explore the world and make observations (using observation templates) with the Book and Quill, camera, and portfolio	4.00
(27): List down the measurements	2.00	(10): After writing down observations, teleport back to the space station lobby	3.20
(28): Explore the world and make observations (using observation templates) with the Book and Quill, camera, and portfolio	4.00		
(29): After writing down observations, travel (teleport) back to the space station	3.20		

Table 4: Average Score for Categorized Tilted Earth Tasks

Task Number	Category	Average Score
1, 11, 20, 29	Teleportation and Journeying	3.50
2, 3, 4, 5, 12, 13, 14, 21, 22, 23	Interactions (bots, instructional NPCs and signages)	3.38
6, 7, 8, 9, 10, 15, 16, 17, 18, 19, 24, 25, 26, 27, 28	Exploration and Observation (tools and measurements)	3.61

The participants were able to complete the tasks for Tilted Earth to a good extent and capacity. Most importantly, all participants were successfully able to reach the base building and receive further instructions and tools for their scientific observations. However, there are minor lapses when it comes to listing down the measurements and knowing when they have successfully completed all tasks, and most were unable to interact with the bots.

#### 4.3.4 No Moon Results

Table 5: Average Score for Categorized Tilted Earth Tasks

Task	Average Score
(1): From the space station lobby, go to the No Moon room and teleport	3.20
(2): Arrive at No Moon and speak to the infobot inside the rocket	3.00
(3): Exit the rocket and read the instructions on the board	3.80

Table 6: Average Score for Categorized Tilted Earth Tasks

Task Number	Category	Average Score
1, 11	Teleportation and Journeying	3.20
2, 3, 4	Interactions (bots, instructional NPCs and signages)	3.60
5, 6, 7, 8, 9	Exploration and Observation (tools and measurements)	3.64

The participants completed the tasks for No Moon by themselves to an average extent. Most notably, all participants were successfully able to go to the greenhouse and receive further instructions and tools for their scientific observations. However, there are minor lapses when it comes to listing down the measurements and knowing when they have successfully completed all tasks and can head back to the space station lobby. One of the pain points as mentioned in the previous What-If worlds is that participants could not immediately tell when they have succeeded with their goals or when they are done exploring the world.

#### 4.3.5 In-Game Experience Results

The results of the in-game questionnaire reveal the participants thoughts and emotions while playing the game. The statements that players answered were also divided into 7 categories, directly patterned after the GEQ from IJsselsteijn, de Kort, and Poels' study [8]. The "Competence" category gauges whether a participant felt skillful and successful. The "Sensory and Imaginative Immersion" category is how much a player was invested in the game. "Flow" tells if the game had a seamless storyline and if players were well immersed. "Tension" is one of the negative categories that indicate if a player was irritated or frustrated while playing. The "Challenge" category reveals how much effort players put into the game. Then lastly, the "Positive Affect" and "Negative Affect" categories indicate whether players had an overall positive

experience with the game (they felt good and content) or if it was negative (they felt bored or it was tiresome for them) respectively.

Table 7: Average Ratings for In-Game Experiences

Category	Statement	Average Rating per Statement	Average Rating per Category
Competence	I felt successful	3.73	3.40
	I felt skillful	3.07	
Sensory and Imaginative Immersion	I was interested in the game's story	4.20	4.24
	I found it impressive	4.27	
Flow	I forgot everything around me	2.53	3.07
	I felt completely absorbed	3.60	
Tension	I felt frustrated	1.67	1.50
	I felt irritable	1.33	
Challenge	I felt challenged	3.40	3.24
	I had to put a lot of effort into it	3.07	
Negative Affect	I felt bored	1.53	1.50
	I found it tiresome	1.47	
Positive Affect	I felt content	3.93	4.17
	I felt good	4.40	

While the participants were playing and exploring the What-If worlds, "Sensory and Imaginative Immersion" and "Positive Affect" were categories with the highest average ratings. Categories with negative sentiments, which are "Tension" and "Negative Affect" had the lowest average ratings. The remaining categories were in the average 3.0 range.

With these results, the researchers can infer that all the participants had a generally fair and positive experience with the game, but there are areas for improvement. Some highlights are that participants found the game interesting and impressive and that they felt good after playing. They also did not feel bored, tired, or irritated. However, personal feelings of success, skill building, and immersion were generally average.

#### 4.3.6 Post-Game Experience Results

The results of the post-game questionnaire reveal the participants thoughts and emotions after playing the game. The statements that players answered were divided into 4 categories based on IJsselsteijn, de Kort, and Poels' GEQ [8]. The "Negative Experience" category indicates if a player felt bad after playing the game, whether it was bad or if the game felt like a waste of time. The "Positive Experience" category shows if a player felt satisfied and even victorious after playing. The "Returning to Reality" category gauges the immersion levels of the game and how players felt afterwards. The "Tiredness" category is how tired a player felt afterwards.

Table 8: Average Ratings for Post-Game Experiences

Category	Statement	Average Rating per Statement	Average Rating per Category
Negative Experience	I felt bad	1.40	1.43
	I felt guilty	1.00	
	I found it a waste of time	1.20	
	I felt that I could have done more useful things	3.00	
	I felt regret	1.00	
	I felt ashamed	1.00	
Positive Experience	I felt revived	2.40	2.93
	It felt like a victory	3.40	
	I felt energized	3.00	
	I felt satisfied	3.80	
	I felt powerful	2.20	
Returning to Reality	I felt proud	2.80	2.33
	I found it hard to get back to reality	1.00	
	I felt disoriented	2.80	
Tiredness	I had a sense that I had returned from a journey	3.20	1.00
	I felt exhausted	1.00	
	I felt weary	1.00	

After playing the game, the participants have reported to have an average of 2.93 score for the category "Positive Experience", and an average of 1.43 score for the category "Negative Experience", which means that, for the most part, the participants had an overall more positive experience after playing the game. For the

category “Returning to Reality”, participants have an average score of 2.33, indicating that it was moderately immersive. Lastly, for the “Tiredness” category, participants have an average score of 1, indicating that it was not at all tiring for them, and they did not feel exhausted after playing.

## 5 Conclusion

### 5.1 WHIMC Migration to MC:EE

Planning for the migration of WHIMC to MC:EE entailed detailing which entities and features can be migrated in its original state or would need to be modified to compensate for the lack of complete compatibility between Minecraft Java and Education Edition. Entities that retained their original state in migration were the What-If worlds instances and their main landscape designs including key structures such as the rocket ships, greenhouses, underground bunkers. The features of WHIMC on Java, otherwise known as the plugins, had been retrofitted to be playable on MC:EE. As such, the plugins Multiverse (teleportation), Quests (observation and measurements), and Citizens (in-game characters), were done on MC:EE using already built-in features in MC:EE such as the NPC, Book and Quill, Camera, and Portfolio items. The migration itself of WHIMC to MC:EE was done with WorldEdit and Forge which allows the simultaneous manipulation of blocks on a wide scale to stitch each of the individual worlds and their respective scenarios into one singular world file.

### 5.2 Player Experience of WHIMC on MC:EE

Through the User Experience Testing of college students with varying Minecraft familiarity, the researchers were able to thoroughly see how WHIMC can be represented within Minecraft: Education Edition for the general audience. Each tester was given only 30 minutes to go through their assigned world and they explored without any guidance from the researchers. Overall, the testers accomplished most of the tasks which served for the general purpose of the WHIMC worlds. The players explored and accomplished their tasks at varying paces which was a direct display of their familiarity with the game. Even players with little familiarity on Minecraft still succeeded with most of what was needed.

As per the post-game experience analysis, the testers came out of the game with a generally positive attitude while also feeling challenged. This is exactly the type of feeling that was most preferred for players to encounter both during and after going through the WHIMC worlds. Based on what the researchers have seen and through the reactions of the players, it is safe to say that the migration of WHIMC to Education Edition has served its purpose. But even with the outcome of the User Testing being mostly positive, there are still a few minor details that need to be polished for a smoother user experience.

### 5.3 Issues and Recommendations

During the user testing, players encountered common difficulties. A common difficulty that players encountered was falling into holes, rendering them trapped inside and unable to move and get out of them. In the original WHIMC, these holes were already present, and it was decided to include them to preserve the accuracy of the Java Edition version. However, seeing as this frequently caused the immobilization of players, there are possible recommendations: (1) To cover up these holes; (2) to make the holes only one block deep so that players may jump out of the hole themselves or (3) to make a new functionality wherein players are teleported instantly out of the hole using in-game features Pressure Plates and Command Blocks.

Another lapse in the game was when players found passageways that made them cross beyond the invisible boundaries. This happened because when barrier blocks were put as boundaries for each of the worlds, they were done so through the replacement of only the air blocks, so that other blocks would be unaffected. However, there are some blocks that do not have the impassable characteristic (e.g., flowers, grass). This led to creating small holes in the barrier, since these kinds of blocks were not replaced with the barrier block. A solution that the researchers thought of is by replacing all blocks without the impassable characteristic with barrier blocks to ensure that there are no unintended passageways outside of the What-if world.

From the results of the user testing, some of the lowest scores were the tasks related to taking down measurements and using the observation tools. It was observed that players were confused by having a new set of observation tools each time they teleport into a new world scenario. What can be done to remedy this is that players will only be given one set of observation tools to use for the entire duration of their gameplay, for all the What-If worlds that they venture to. This singular set of observation tools can be given as soon as the player steps foot into the space station and reads the instructions.

Moreover, most players were also unsure of when they could end their gameplay. To provide users with a concrete indication that they have completed their tasks for the world, the researchers thought of using the same implementation as the Measurement Building which requires players to insert a Diamond item in a Dropper to open the door. But for this case, at the end of each task the player would be given an item which they will insert into the Dropper and will activate a lever which will light up a Lamp, indicating that they have indeed completed the task.

Overall, WHIMC on MC:EE still has a lot of room for improvement, but this research work was a good initial step for bringing the project onto a more accessible Minecraft platform.

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# BALA: STEALTH FIRST-PERSON ACTION GAME DEPICTING THE PHILIPPINE REVOLUTION OF 1896

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## ABSTRACT

Video games tackling different historical events has been a popular genre of gaming. These games are labeled as ‘historical games’ with varying degrees of historical accuracy. To date, there are no notable games depicting the Philippine Revolution of 1896. Depicting our history through video games can be a helpful gateway for appreciating our history and for the possibility of recreating Philippine historical events through video games.

This project aims to create a first-person action shooter that depicts the early stages of the Philippine Revolution, particularly the Battle of San Juan del Monte. The historically inspired video game will depict the context, uniforms, and weapons used by the Philippine Revolutionary Army during these times, as well as give key historical information about the battle and the revolution. The game is built using the Unity game engine for Windows platforms.

To determine the effectiveness of the game in depicting the historical setting, ratings on user interface, gameplay, graphics, difficulty, and fun were made on five participants. Testing showed that the historical setting was positively received along with the gameplay. Improvements are needed on the user interface and graphics side of the game, however. The study concludes that depicting the Battle of San Juan del Monte in a video game can be positively received by students, given that the gameplay, difficulty, and graphics are properly made.

## CCS CONCEPTS

- Computer games

## KEYWORDS

Video games, Philippine Revolution, Philippine history

## ACM Reference format:

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## 1 Introduction

Video games have been a rising popular medium for entertainment with sales increasing to \$43.4 billion in 2018 [1]. Through interactivity, video games can provide players with

different stimuli and information for the players to process and decide. This medium has been an effective tool for platforming ideas such as raising awareness about mental health, like *Binding of Isaac* which is an artistic representation of coping mechanisms [2]. This immersive platform can benefit other topics that are generally lacking in interactivity such as history. Allowing a player to experience a part of history that is interactive and entertaining may inspire players to explore and give more time to learning about this part of history [3].

One example of this approach is the game *Igpaw: Intramuros* [4]. It used augmented reality technologies to create a serious game that allows players to learn more about the history of Intramuros and historical characters using a non-formal form of learning. This kind of application can be a starting point for more time-specific or place-specific applications for displaying historical locations and events in Philippine history.

However, more popular games belonging to the historical genre depict a part of world history into their setting, mechanics, plot, or gameplay as a tool for entertainment and not for learning. Games like *Total War: Rome 2* [5], *Assassin’s Creed 3* [6], and *Civilization V* [7] are a few examples of such games. These games are mainly for entertainment and enjoyment, with historical information being shown to the players as a side note. *Civilization* has been a particular game title used in much academic research on using video games as tools for learning history, focusing on historical inquiry, and increasing the interest of students in learning history outside the classroom [3].

The objective of this study is to create a game with a creative representation of the early stages of the Philippine Revolution of 1896. The game depicts a soldier performing courier duties for the Filipino revolutionaries or *Katipuneros* to show the weapons and situation of the revolution during these times.

This study aims to answer the following questions:

1. How will the researchers depict the *Katipuneros*’ operations during the 1896 Philippine revolution through a stealth first-person action game?
2. Which aspects, weapons, and operations of the *Katipuneros* during the revolution should be included in the game?

3. What game elements should be included to creatively portray the locations and people during the 1892-1896 Philippine revolution?

4. How effective is the game in informing the players about the Katipuneros used during their operations?

5. How fun is the game?

This project is segmented into levels and is not to be considered as a collective map of the revolutionary movements. The project is inspired by the Battle of San Juan del Monte. Creative liberties may be taken with depictions of certain areas and events to enhance gameplay. The game is not aimed as an educational tool for teaching history, but it is hoped that it will generate interest in Philippine history. Moreover, the game's target audience will be college students, which is in line with the suggestion of the Pan European Game Information that the audience be 16 years old and above since the game will tackle themes such as the use of bad language and violence [8].

This project can inspire players to read up on the history being depicted in the game, taking advantage of the recent developments in making the technology cheaper and accessible [9] and allowing users to have a more engaging way to learn about the revolution during 1896. This is also a proof of concept for using historical events of Philippine history for game design and setting. It can provide an interactive perspective of a time period that is difficult to grasp by plain pictures, diagrams, and textbooks usually depicted in classrooms.

## 2 Review of Related Literature

The inspiration for the setting of Bala is the eastern forces led by Andres Bonifacio, the Supremo of the Katipunan (position is similar to a Commander-in-Chief). Before the eve of battle, Katipuneros were in high hopes as more troops began to coalesce in Balakbak, the temporary headquarters of Bonifacio, such that it was compared to a fiesta [10].

However, the Spanish government was able to discover the Katipuneros' plans to the point that Spanish Troops have been sent to strengthen vulnerable locations such as the Polverin (gun depot and armory) and the El Deposito de Aguas Potables (waterworks); these two locations were important for the Katipunero's advance as it would have provided weapons and ammunition [10]. Knowing how well-fortified the Polverin and the El Deposito were, Bonifacio opted to carefully surround the strongpoints rather than engaging them head-on but this plan was thwarted as more well-armed Spanish artillery and infantry began to engage the Katipuneros in the area [10].

As the Katipuneros ceded ground to the Spanish troops, Bonifacio and his lieutenants slowly lost control of their men due to the confusion created by the Spanish army's pursuit [10]. More casualties were inflicted by the Spanish Cavalry as small groups of Katipuneros were surrounded and captured.

One reason the Katipuneros lost to a significantly outnumbered Spanish force was that the Katipuneros were not able to match the guns and the artillery brought by the Spanish troops [10]. The Katipuneros fielded over 2,500 men but were only armed with around 50 firearms which were an assortment of muskets, modern rifles and revolvers, and improvised firearms [10].

This difference in firepower pushed Katipuneros into creating their own crude firearms. Jose Ignacio Pawa, a Chinese blacksmith, operated smiths where guns can be refitted and ammo can be made; from these same smiths, Pawa made cannons out of bamboo and crude muskets from sturdy metal tubes [11]. In addition to improvised firearms, darts and bows were also used where troops were ordered to be equipped with a bow as tall as the user and to always keep a quiver of 30 arrows [11]. The most common weapons for Katipuneros were the iconic bolos which were used as tools to cut vegetation but more warfare-oriented weapons were also used such as the kris used by Moros and the gulok [11].

Historical information can be presented in many media formats depending on the intended use of the information. Video games in particular have been a popular medium for this. Although world history is used in video games as settings, contexts, or backdrops for the video game itself, some games go above and beyond on historical accuracy and representation. A paper written by Spring details the use of video games to teach history and the use of it in historical scholarship [12]. Many popular historical video games like Total War, Assassin's Creed, and Europa Universalis were cited as good examples of such video games. Primary sources are translated into historical play spaces, mechanics, settings, characters, and material culture. A balance of good game mechanics and historical representation is mandatory for scholarly games. Picking game mechanics is important depending on what historical event is being depicted.

An important aspect of the historical narrative of the Battle of San Juan del Monte that will be portrayed is the inadequacies of the Katipuneros' tactics and equipment. Because of this, the stealth mechanics inspired from different games will be considered to simulate the Katipuneros trying to fight a better foe. The enemy artificial intelligence (AI) in Bala will be better armed and can coordinate with other AIs to corner and hunt down the player. The player will be forced to be creative and avoid direct confrontation with the enemy AI in order to progress. Finally, to ground the game and create a more engaging narrative, real-life characters that were present during the battle will be adapted to fit the game.

## 3 Methodology

### 3.1 Initial Research

The researchers looked at historical references about the Battle of San Juan del Monte and the Philippine Revolution of 1896 for setting, weaponry, clothing, locations, army organizations, and other relevant information. Weapons and operations of the Katipuneros depicted in the game will be limited to this specific event only.

Descriptions of weapons, especially the paltik and other weapons, were taken from the articles of Richardson and Ocampo but these descriptions are mostly in text, and images of the actual weapons are hard to find. Because of this, creative liberties were taken in depicting these weapons. Historical characters such as

minor and major leaders of the Katipunan were picked as NPCs or important characters for the players to recognize in the game.

In depicting the historical objects and persons, the researchers focused on historical authenticity and game experience. Historical authenticity in this case means the objects and persons found in the game can fit within the historical context of the setting even if, in reality, there is no concrete evidence that they were present in the scene. In addition to this, the game experience is another objective, such that the objects and persons in the game serve to push the gaming experience of the player to be more entertaining and fulfilling.

### 3.2 Game Design and Structure

The game was made to be a first-person shooter with stealth mechanics. Since the character is a courier that delivers correspondences, letters, or war implements while staying undetected, stealth and shooter mechanics are needed. Based on the information available, stealth, shooting elements, and tactics can be implemented through mission objectives like escaping and game mechanics like avoiding patrols.

Other elements like landscape can be inferred from the historical sources for the level design and aesthetics. Creative liberties on some specific locations the players to interact with have been made. Some objectives and missions may not reflect historical events for gameplay purposes. These game assets will be created parallel to the development of the game mechanics. Uniforms based on availability of historical sources were made. For the gun depictions, the player's main weapon, the paltik, is a matchlock musket, which closely resembles the improvised guns used during the early stages of the revolution [11].

### 3.3 Game Development Life Cycle

The development process will consist of storyboarding, asset creation, sound design, level design, game mechanics implementation, and testing. A workflow in Notion will be used for documentation and checking for the current progress of the game. The development life cycle will follow a Kanban methodology on delivering outputs to the game. The methodology allows small incremental outputs on a project that has many working features that need to be developed in parallel and integrated with the other existing or developed systems [13]. The processes will be divided into small subtasks with label indicators whether they are asset creation, sound design, level design, etc.

A Git repository was established for version control and collaborative working on the project. Unity will be used as the development engine for the game. Custom assets and animation will be made in Blender. The project will be developed and deployed exclusively on Windows 10 machines to focus on development and bug fixing that may arise from other machines. The game will be available for download via itch.io.

### 3.4 Game Evaluation and Data Gathering

The target population for the project were currently enrolled students in the Ateneo de Manila University that are 18 years old and above. They also should have taken or are currently taking either HISTO 11 (Rizal and the Emergence of the Philippine Nation) or HISTO 12 (Readings in Philippine History from 1896 to 1986). From this demographic, social media announcements were made for testing and are eligible to test if they meet the criteria. Priority will be given to students still currently taking the mentioned classes. Eligible testers will be asked of their experience of playing first-person shooter games and historical games.

The testers will be given a pretest via Google Forms to determine their knowledge about the subject matter (Philippine Revolution, weapons, tactics, and people). After taking the pretest, they will be given a maximum of 30 minutes to playtest the game under the supervision of the researchers.

After the testing, the tester will answer a posttest to check if they have gained knowledge from the game. The posttest also contains what they learned about playing the game. The questions here are similar to the pretest, with additional questions on additional insights learned on the game. After the posttest, the tester will undergo post-processing to evaluate the game's content, design, aesthetic, difficulty, and points of improvement which will be noted by the researchers.

## 4 Results and Discussion

### 4.1 Features and Implementations

**4.1.1 Interface.** For the main menu, the current build of the game only allows the player to go through the first level "Firefight" which introduces the premise of the game.

When going to the level screen, a briefing will inform the player on the scenario and the situation at hand. This introduces the historical context of the game and places the player in their role.

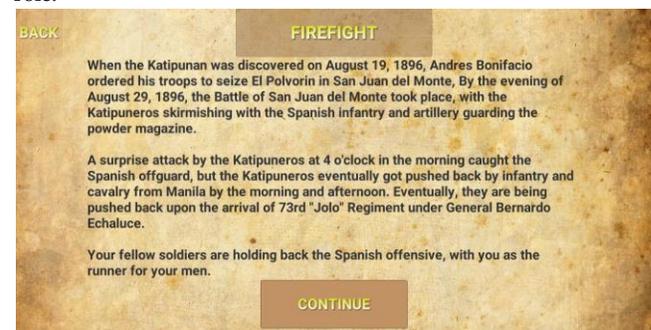


Figure 4.1 Level 1 Menu Screen

The game's user interface (UI) has a minimal heads-up display, displaying the fixed minimap on the top right, and the bullets of the current weapon equipped on the bottom right. The camera is controlled by moving the mouse button. The minimap is a fixed player-on-center map that displays the player and indicates their position and orientation.

**4.1.2 Movement.** The game allows the player to perform basic first-person movement, crouching, sprinting, and jumping. First-person movement includes moving forward, backward, strafing left, strafing right, and camera movements. Sprinting speeds up the player's movement speed for a limited amount of time before putting it into cooldown to be able to run again. Jumping allows the player to go over certain terrain obstacles. Crouching allows the player to conceal themselves in the foliage to avoid detection while also reducing the movement of the player. This avoids detection entirely unless the player has already been detected earlier.

**4.1.3 Shooting.** Two weapons are available for the player to use: a paltik which serves as the primary weapon, and a sumpit which is a secondary weapon. The paltik is designed to be a matchlock musket to portray the crudeness of the weapons by the Katipuneros during the time period. It is a loud weapon that attracts enemy attention when fired either from the hip or aimed. This weapon only requires one shot for the enemy to be killed.



**Figure 4.2 Paltik Inspiration**



**Figure 4.3 Paltik in the current game build**

The sumpit is a blowdart and is an alternative for the player for a stealthy and non-lethal approach. Sumpit allows the player to put an enemy hit to sleep, making the enemy unable to move and detect the player for a short amount of time, but can only be fired when aiming. Both weapons have animations for switching, aiming, firing, and reloading.



**Figure 4.4 Sumpit Inspiration**



**Figure 4.5 Sumpit in the current game build**

**4.1.4 Enemy AI.** The enemy AI has its own model with its own set of animations for walking, moving, aiming, and firing. The AI uses Unity's AI package for its movement and avoidance of obstacles. AI have designated patrol routes which are defined by certain points in the map. The AI detects the player when the player is in its line of sight, or when the player fires its paltik. The AI has a sound cue "¡A las armas!" (lit. To arms!) to know that the player has been detected. From there, the AI is on indefinite "alert" mode that chases and shoots the player on sight. The AI can also inform other AI instances which are within a certain distance upon being alerted of the player's presence. The AI shooting their weapons also alert other AI to the player's location. If the player successfully escapes the enemy AI, the AI will return to its patrol route. When the enemy AI is hit by the sumpit, the current AI will just stay and not move, giving the player some time to move undetected.



**Figure 4.6** “Wolf pack” behavior of AI indicated by the purple lines



**Figure 4.7** Model for Spanish troops

**4.1.5 Levels.** The game currently has 4 levels. The first two levels are considered to be tutorial levels, where some of the controls are first introduced, while the third level serves as the first mission of the game’s character.

For Level 1, the player is introduced to the game with cutscenes and instructions on how to play the game. Instructions presented include aiming, shooting, reloading, and movement. This level mainly allows the player to familiarize themselves with controls, while also being introduced to the story and what to do next. As a tutorial stage, enemies in this stage aren’t actively shooting and chasing the player. The objective of the level is to reach the far side to continue to the next level.



**Figure 4.8** Level 1 Sample Cut Scene

Level 2 introduces the stealth and melee mechanics of the game to the player. The player will also be prompted to use the sumpit for this level. This introduction to stealth is separated from Level 1 to provide the players with different gameplays, but with preference towards stealth and properly executed movements. The objective of Level 4 is to reach the treeline, regardless of whether the players defeat all the enemies, or go through it stealthily.

Level 3 presents the target mood and design for the whole game. The players will test their stealth capabilities and be wary of enemy detection. The objective of Level 3 is for the player to reach the bridge without dying from the enemies.

Level 4 is currently the biggest map in the game. This level requires stealth and strategy from the player to reach the objective. The map is littered with enemies; thus, the player will need to pass through a certain path to remain undetected. The enemies featured in this level are both patrolling and stationary. The stationary enemies will only move when the player is detected. The goal of this level is to reach an area and eventually escape the encirclement.



**Figure 4.9** Level 4 Level Design

## 4.2 Initial Beta Testing Results

An initial beta build has been tested by volunteers during the three-day period of testing. The comparison of correct answers from the pre-test and post-test answers by the participants is listed below:

Table 4.1 Pre-test and Post-test Results Comparison

Question	Pre-test (# of correct / # of respondents)	Post-test
Uniform Question #1	4 / 5	4 / 5
Uniform Question #2	4 / 5	4 / 5
Uniform Question #3	5 / 5	3 / 5
Katipunan's organization	5 / 5	5 / 5
First battle	2 / 5	4 / 5
Weapons	5 / 5	5 / 5
Meaning of KKK	3 / 5	3 / 5

Overall, the respondents scored highly during the post-test, which can hint to a possible learning they have taken when playing the game. One note in particular is the increase in the question about the 'first battle', which saw two respondents answering correctly. The first three questions ask whether the following uniforms were worn by the Katipuneros during the early stages of the Revolution. The question #3 shows a uniform of a Spanish soldier from Cuba. The respondents may have been confused on the game prompt where the Katipuneros would steal uniforms. This partial data set of five respondents show that the respondents already have a solid knowledge of the historical topic even before the testing.

Feedback from the game was also collected based on the following criterion: overall rating, gameplay, graphics, user interface, difficulty, and fun.

- Overall rating describes their entire experience of the game and not the average of all the scores they have. This is rated from 1 (very negative experience) to 10 (very positive experience).
- Gameplay pertains to the mechanics of the game itself, and how the player interacts with the game. This is rated from 1 (negatively affects the experience) to 10 (enhances the experience).
- Graphics pertains to the visual aspect of the game, how the game looks and feels. This is rated from 1 (negatively affects the experience) to 10 (enhances the experience).
- User interface describes the visibility and usability of the game's user interface, and its usefulness in the game. This is rated from 1 (negatively affects the experience) to 10 (enhances the experience).
- Difficulty pertains to how enjoyable the difficulty is for the players and does not measure how easy or hard the

game is. This is rated from 1 (negatively affects the experience) to 10 (enhances the experience).

- Fun pertains to how they enjoyed the game as they went through it. This is rated from 1 (frustrating to play) to 10 (very enjoyable to play).

Table 4.2 Criterion Ratings from Post-Processing Interview

Criterion	Mode	Lowest	Highest
Overall rating	7	7	7
Gameplay	8	5	10
Graphics	5	5	6
User interface	5	4	9
Difficulty	7	3	8
Fun	9	6	9

Based on the data collected, the most notable criterion is the fun or enjoyment aspect of the game. 4 out of 5 testers expressed enjoyment on the stealth aspect of the game. Linked with this is the gameplay, where people also expressed high ratings on this criterion. The objectives are clear but there are certain mechanics that are confusing. The mouse sensitivity of the game is also too high that some testers are not able to aim properly. Different gameplay approaches were also observed during the testing/ Two testers tried to exploit the AI's chasing mechanics and the implementation of movement to defeat all the AIs in a map. Two testers tried to stick with the stealth mechanics, and one tester tried a mix of both. The stealth and gunplay mechanics were highlighted as the interesting part of the game, with three testers expressing the need for improvements and clarifications on other game mechanics like detection or melee.

On the difficulty rating, four testers found the difficulty to be doable and added to the experience of the game. One tester expressed that the sensitivity is too high and affected the difficulty of the game. Another tester expressed that the last level added a strategy aspect to the game which added an enjoyable difficulty.

The game also received low ratings on the graphics and user interface. On the graphics side, there are no inconsistencies in the overall graphic design of the game (e.g., smooth gun model but rough ground textures). The user interface was not helpful for four testers, saying that the black text for the ammo count is not visible in many cases. The dialogue is also not as engaging since the texts are small and too quick to appear and disappear. The tutorial for the second level, which introduces the stealth mechanics, was not engaging.

## 5 Conclusion

### 5.1 Implementation of Results

The game design implemented was not fully historically accurate but was modeled to be historically authentic to the experience of a regular Katipunero. In this way, two main mechanics were implemented: the stealth gameplay and the first person shooting. Both created an experience where the player would have to learn how to sneak around the enemies and to smartly use their weapons to achieve their objective.

For the enemy, an AI was created that could communicate and coordinate with each other. This prevented the player from running through levels and from aggressively using their loud weaponry. The player can also take advantage of the level design where debris, huts, trees, and bushes can be used to hide from enemies. However, as a last resort, weapons with limited ammunition were provided to help the player.

In addition to this, historically inspired uniforms, weaponry, and characters were used to further immerse the player as well to inform the player about the historical period. Notably, these were the sumpit and the paltik. More explicit information about the time period was provided in-between levels using through loading screens.

## 5.2 Testing Results

The game was well-received in terms of the topic being discussed. A PC shooter game about the Philippine revolution is unheard of, according to the testers. The combination of a familiar history and familiar game mechanics of first-person shooters made the testers enjoy the gameplay and the theme. However, there are notable shortcomings that were highlighted as well.

Some AI behaviors were inconsistent according to the testers, most likely due to a lack of visual cue for detection. Due to these, AI behaviors were exploited to ‘rush’ the objectives and proceed to the next one. Some mechanics like melee and the sumpit were not used to the fullest extent but were acknowledged to be options to approach the game. The stealth and detection mechanics’ flaws were also seen on each of the stage’s level designs.

The graphics and user interface requires huge improvements due to the low scores it received. The user interface is not always visible due to the lighting and the game’s color scheme. The graphics of the guns and characters in contrast to the environmental objects are inconsistent in presentation.

## 5.3 Recommendations

The testers noted multiple suggestions for the improvement of the game. For the quality-of-life changes, some testers suggested adding an option to adjust the sensitivity for aiming. These testers noted that the current sensitivity for aiming hindered them from playing properly and more accurately. Other testers also recommended that an option for adjusting the audio volume should be added.

When it comes to the user interface, most testers suggested it to be more responsive based on the user’s screen. They also suggested more visible graphics, pointing out that the texts were

too small, and that the ammo counter can’t be properly seen due to its dark color that blends on the background’s color.

For the gameplay, testers advised the researchers for an improvement of the tutorials featured in the game. A tester asked for it because some tutorial instructions went away too fast. Aside from this, testers also recommended a more consistent graphics since some components of the game have smooth graphics while the others looked rough. Lastly, the testers suggested that a mechanic for picking up weapons and ammos be added to the game.

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# In-Between Frames: An Animation Adventure

A 2D Action Metroidvania that uses the Principles of Animation in Gameplay

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## ABSTRACT

This paper aims to show that a video game can be an alternative method in introducing certain concepts of animation. The researchers created a modified 2D metroidvania video game that teaches its players the basics of animation throughout the course of the story and its underlying game mechanics. This game is wholly programmed in Godot version 3.3.3 and is playable only on machines that run Windows 10.

## CCS CONCEPTS

CCS → Applied computing → Computers in other domains → Personal computers and PC applications → Computer games

## KEYWORDS

Animation, Video Games, Metroidvania, Educational Games

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## 1 Introduction

Animation is the display of static images in a rapid manner that creates the illusion of motion. It is present in almost every form of media, from full feature-length films to simple moving text and elements on screen. The animation industry has grown substantially in the past decade, having an industry-leading output value of \$220 billion in 2016 globally [16]. Advances in technology and increasing market demand have made it possible for the industry to grow, increasing budgets and production quality, and more mediums of showcasing animation [15].

### 1.1 Context of the Study

Animation has a major part in entertainment [17] ever since its industry boom in the last century, with uses that transcend its roles in movies and cartoons [19]. It is also heavily used in social media and marketing because of its flexibility and exposure. However, many studios still do not fund their artists and animators appropriately, leading to an unhealthy industry standard that underpays its animators [8]. Despite this, many new animators are still entering the industry, regardless of its production value growth issues [24]. Additionally, there are now more ways an individual could get into the art, whether it be through free animation software or online tutorials. This process of learning the basics of animation could be gamified as seen with Toontastic 3D, a gamified animation/movie maker aimed at children.

### 1.2 Research Objectives

The main objective of the study is to develop a video game, *In-Between Frames: An Animation Adventure*, that will educate its players about animation. The video game should allow players to experience the process of animation in a simplistic but still informative manner. It should also teach the players a set of principles that are commonly used in the art of animation.

### 1.3 Research Questions

This study aims to answer the following questions: (1) How does one create a video game that educates its players about animation while maintaining a fun and interactive experience? (2) What game elements can be used to represent the animation process? (3) How effective is the video game in introducing the principles of animation to its players? (4) How fun is the video game?

### 1.4 Scope and Limitations

The video game will be created using the Godot Engine version 3.3.3 and will be playable only on machines running Windows 10. The target audience of the game are people who are interested in animation and would like to experience animating in a casual environment. The game's complexity and theme will cater to teenagers and young adults, more specifically those

who are aged 13 to 25. However, the play testers that will be chosen will only be people of legal age, from ages 18 to 25, to avoid additional paperwork when asking for the consent of the guardians of minors. This may prove to be a limitation as the researchers will not be able to get data from younger players. The extent to which the game will replicate the process of animation will be based on a set of animation principles that will be discussed in Chapter 2.

### 1.5 Significance of the Study

With the prevalence of animation, whether it be used in feature films or user experience design, comes a rise of interest in pursuing the art [2]. The Philippine animation industry is known for outsourcing its services to the global markets, for films, television shows, and video games [4]. While it has maintained its services, it has also maintained its marginal global market share due to lack of infrastructure, funding, and support in the local landscape. *In-Between Frames: An Animation Adventure* is not intended to be an alternative to actual animation education, but could serve as a gateway into pursuing the art. With games such as *Minecraft* having a role in education among its young player base [6], a game that can present the processes involved in animation and its principles could potentially inspire players to go into traditional or digital animation.

## 2 Review of Related Literature

In this review, the important aspects included in *In-Between Frames: An Animation Adventure* will be discussed, such as the 12 principles of animation [22] and terms in 2D and 3D animation, along with various references for these, such as games and animation software.

### 2.1 The 12 Principles of Animation

*In-Between Frames: An Animation Adventure* aims to teach its players principles that come from Chapter 3 of the book *The Illusion of Life: Disney Animation*. Of course, these principles may not apply to all kinds of animation. Some of these principles may not be used for a number of reasons, such as comedic effect or closeness to reality. The researchers chose these principles as they are very prominent in most animations, and the book documents them very well.

**(1) Squash and Stretch.** Squashing and stretching a character creates the illusion of elasticity, volume, and flexibility. It is commonly used to exaggerate movements and to make characters more dynamic.

**(2) Anticipation.** Anticipation helps viewers discern what a character is going to do next. This can be as simple as a character crouching before running or winding up for a punch.

**(3) Staging.** This refers to the direction and focusing of the animation. The animation should have control over what, when, and where the focus of the viewer is on. For example, wide shots of a character should usually contain a large action

like jumping. On the other hand, close-up shots are used to focus on the emotions of the characters. It is also important to not have too much information in one shot, and space out important events.

**(4) Straight Ahead Action and Pose to Pose.** These two are approaches to creating animation frames. Straight Ahead Action means creating each frame chronologically. This has a disadvantage in that the animator is more prone to losing track of the dimensions of the character and the length of the animation itself. On the other hand, Pose to Pose means creating the keyframes or at least important frames first before creating the inbetweens. These two approaches are usually used in complement to each other.

**(5) Follow Through and Overlapping Action.** These are the 'inertia' of animation. For example, a girl coming to a sudden stop after running will have her hair move some distance forward before actually coming to a halt. These principles say that no object has its parts stop at the exact same time.

**(6) Slow-in and Slow-out.** These principles are the other half of the former. In real life, nothing snaps to movement or to a halt instantly. There must be a transition from movement, to slowing, and to stopping and vice versa. For example, a car has to go from a halt to 60km/h in a smooth manner. If it instantly snaps to 60km/h, all of its passengers would break their necks. Unless a comedic effect is desired like in some cartoons, such an instantaneous change of speed is not applicable in most cases.

**(7) Arcs.** No things move in straight lines. Objects with a fixed length will always move in arcs. An example is a person swinging a stick with their arms. The stick and the arms of the person will not move in a straight line, rather they will revolve around the person in an arc.

**(8) Secondary Action.** Secondary Action simply states that for a scene to be more attractive, the subject must be doing something else other than its primary action. This action should complement the primary action, like a person reading a book while scratching their head.

**(9) Timing.** Timing of the number of drawings is important in animating actions. An action that has a high number of drawings will make the animation look smoother, but slower. On the other hand, the same animation with fewer frames will look snappy and quick.

**(10) Exaggeration.** Animators commonly exaggerate movements and actions to make their animations more dynamic and appealing. Some of the usual exaggerations take place in the movement of the body and the expressions of the character.

**(11) Solid Drawing and Solid Posing.** The subjects in the animation should be posed clearly and expressively. The subjects should still be understandable even if they were only silhouettes of themselves.

**(12) Appeal.** The audience should be drawn to the animation and its characters in some way through design,

simplicity, significance, whether it be a hero who is strong and selfless, or a villain who is charismatic and mysterious.

## 2.2 Traditional Animation: Keyframes, Breakdowns, Inbetweens

In Traditional Animation, there is the concept of keyframing. This refers to the drawing of individual images that depict movement. A key or an extreme is a key moment in an animated sequence. A single animation can have several keys depending on how complex that animation is. A keyframe is the drawing that corresponds to those keys. A breakdown is a frame between the keyframes that describes the motion between the keyframes. Finally, the inbetweens are all the frames between the keyframes that make the motion smoother [14].

## 2.3 3D Animation: Keys, Channels, Inbetweens

In 3D animation, keys behave differently. Keys are also called events or time marks. These keys are associated with parameters such as vertex position, shaders, cameras, etc. Every key associated with an individual parameter is stored in a Channel. Inbetweens fill the gaps between the keyframes using several interpolation methods that compute the motion from one key to another.

## 2.4 Related Games

The following are video games from which some of *In-Between Frames: An Animation Adventure's* mechanics are borrowed and modified.

### 2.4.1 Indivisible

*Indivisible* is a 2D action metroidvania that features several characters, each with their own style of combat.

The combat system of *Indivisible* allows the player to use up to four characters for each button (face buttons). This allows for an interesting combo system as the player can mix and match which characters they would choose to attack with. Each character can attack up to three times before going into a cooldown timer to prevent spamming attacks [12].

### 2.4.2 The Caligula Effect

*The Caligula Effect* is a modified turn-based role-playing game focused on dungeon environments that lets its players have four out of the nine playable characters in their active party.

*The Caligula Effect* has a battle phase that allows each active character to chain up to three moves. In addition, there is also a timeline to allow the player to see what their selected actions will do ahead of time and see how the enemy will react [20].

## 2.5 Role of Animation Software Behavior in Proposed Game

In order to make the game more realistic in terms of recreating the animation process, i.e. the animation timeline, the researchers turn to various animation software for reference.

### 2.5.1 Clip Studio Paint

Clip Studio Paint is a digital painting software which boasts a lot of versatility in terms of the amount of tools and features that it provides artists, housing framing tools, animation assists, and more intricate tools that can be utilized by animators [9].

### 2.5.2 Blender

Blender is an open source 3D modeling, rigging, animation, simulation, and compositing software created by Ton Roosendaal [1]. Blender is used in many animations, whether it be feature length 3D animated films or in game development.

Parts of Clip Studio Paint's user interface and features for animation are similar to Blender's animation timeline that consist of the channels on the left panel, the playback controls on the top panel, and the timeline itself on the middle panel. Keyframes in the timeline are shown as small diamonds and tweens are shown as colored-in lines linking several keyframes in the same channel [23].

These features inspire the design decisions and implementation of game mechanics such as the usage of a timeline as a backbone of how attacks will be made with the goal of representing the animating experience to the player whilst playing the game.

## 2.6 Relevance of Animation and Industry, History

The history of animation dates back hundreds of years before the first moving picture [7]. Victorians seemed to have first had a grasp on the concept of animation through rotating stills [13]. With all of these early concepts of stills illusioned to be moving through rapid changes of states, the first ever recorded animation was J. Stuart Blackton's *Humorous Phases of Funny Faces*, where he used stop-motion technique to make his drawings on a blackboard come to life.

At 14 frames per second and with a 70-minute length, *El Apóstol* was the first ever full-length feature animation film. It was a huge leap forward in animation history and was also profitable [25]. Many notable names have arisen to the mainstream such as Walt Disney and The Fleischer Brothers. Today, the animation industry market records a whopping \$250 billion to \$270 billion, and is expected to grow even more [18]. Animated feature length films do well in the box office according to Statista, and, thanks to many great recent hits like *The Incredibles 2*, *Frozen*, and *Shrek*, have shown that the animation industry is a force in the movie industry. The animation industry has grown over the years as more and more animation studios other than Disney, such as Dreamworks,

Illumination Entertainment, and Studio Ghibli are able to gather fans [11].

## 2.7 Animation Education

There are numerous animation degree programs that are available to aspiring animators today. Many local universities offer Animation as a course and many more are available as online courses [10]. These courses and programs often teach students the principles of animation, drawing, storyboarding, all along with numerous other computer technical skills such as 3D modeling, and post-production [5].

## 3 Methodology

### 3.1 Design

#### 3.1.1 Intended Experience

*In-Between Frames: An Animation Adventure* falls under the modified metroidvania game genre. It intends to teach its players the very basic animation principles by having them piece together keyframes and add effects. For more details, see Appendix A for the game design document.

#### 3.1.2 Pre-development Data Gathering

The researchers used Chapter 3 of the book *The Illusion of Life: Disney Animation* as the basis for the principles taught in the game. In addition, the researchers consulted with a subject matter expert for other references. With these, combined with collective feedback from advisors, the researchers have gathered information to best tackle the development and design decisions for the game.

### 3.2 Development

#### 3.2.1 Hardware

The video game is available only for PC and requires hardware that can run Windows 10, and a standard keyboard and mouse input.

#### 3.2.2 Software

The researchers used Godot version 3.3.3 as the game engine for the development of the game. This includes the development of the systems that would simulate the processes of animation, the game's world and level design, and any other system related to the game.

In order to create the game's assets, which include art, sounds, etc., the researchers used various art software. Art assets such as backgrounds, foreground elements, character designs, basic 2D animations, etc. were made using a combination of various art programs like Clip Studio Paint, Adobe Photoshop, and Adobe Illustrator. Sounds and music

were both produced by the researchers and taken from open-source libraries.

Notion was used for project management throughout the course of the development cycle. Git was used for version control.

#### 3.2.3 Development Cycle

The researchers followed the Agile Scrum development cycle, where flexibility is the key to adjust to the researchers' different schedules.

The development process was split into several sprints where each team member is assigned different tasks on working on different features for the game. Agile meetings kept communication between researchers constant and allowed any last-minute changes and decisions to come through.

### 3.3 Testing

#### 3.3.1 Playtesting

Testers were anyone aged 18 to 25, and were in one of two categories, namely, Category 1 - people who have no knowledge or limited knowledge of animation, and Category 2 - animation students or those who are knowledgeable of the concepts. The focus of the testing was mainly on the Category 1 testers, while the insights from the Category 2 testers were taken into account for future development of the game. The target number of play testers for Category 1 is 30 people, while Category 2 has a target of 10. Both categories of playtesters tested the game at the same schedule.

The researchers reached out to the public using social media and university organizations. Potential testers were given a survey to gauge their knowledge of animation. The survey was conducted with Google Forms that contains questions pertaining to the person's knowledge to make sure that the volunteer playtesters fit in the requirements that align with the goals of the research paper. If the participants are deemed fit to participate in the playtest, they will then be notified through email that they can join.

The chosen testers were sent links to the downloadable executable file containing the game demo and were given, at most, a week to playtest the game in their own time and pace while taking note of any problems, difficulties, and bugs they may encounter.

#### 3.3.2 Post-development Data Gathering

The researchers created two separate Google Form questionnaires catered for each of the categories of testers. The questionnaires mainly asked the testers qualitative questions about their experience playing through the game demo and their thoughts on it as a gateway into learning animation and garnering interest in it. Additional questions about concepts and principles learned through the video game were also included in the post-development data gathering to serve as a

reference for anything that Category 1 testers might have learned. Along with the executable file for the game, a separate Google Form was sent for bug reports, should the testers encounter them.

### 3.3.3 Analysis Procedure

The answers from the Game Experience Questionnaire in the post-playtest surveys will be used to determine how fun the game is and how the players think of the game as entertainment. These were used to see which features of the game need improvement and adjustment.

The answers to the remaining questions in the post-playtest surveys were compared to the pre-playtest surveys to see if the playtesters had learned more about animation concepts through the game.

## 4 Results

This section contains information about the mechanics of the developed game and the results of the playtest.

### 4.1 Game Mechanics

The game employs several systems that simulate the processes of making an animation and makes use of the 12 principles of animation as well as other animation concepts such as keyframing.

#### 4.1.1 The Animation System

The game features an animation system that allows the player to manipulate the animations of the player character for traversal and combat. It uses an animation timeline shown in Figure 1 where the player can place individual keyframes in any order to animate the character.

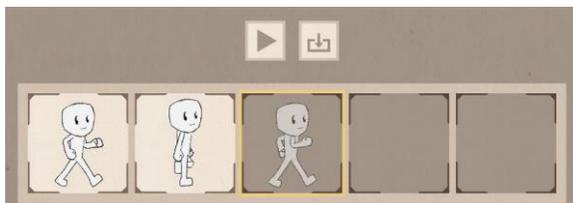


Figure 1: Traversal Animation Timeline

The order in which the keyframes are placed can change the traversal stats of the character. There are three different animations the player can set for traversal; namely the walk animation, the jump animation, and the crawl animation. The keyframe order affects walk speed, jump height and crawl speed.

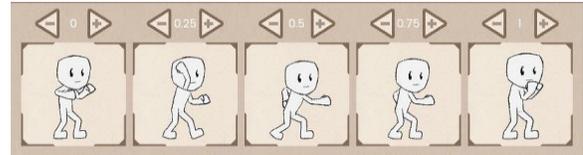


Figure 2: Combat Animation Timeline

The player is given four kinds of attack animations, an attack that uses the left arm, right arm, left leg, and right leg. The combat animation timeline uses a slightly different timeline (Figure 2) than that of the traversal animations in that it allows the player to set the timing of the keyframes placed within the timeline. Changing the time between each frame can change the length of the animation. A longer animation would do more damage than a shorter animation, but will be much slower to perform in combat compared to a shorter animation attack.

Another feature of the combat animations is the use of breakdowns to change the properties of an attack animation. An attack animation has four components; a windup, a breakdown, a hit, and a follow through. The breakdown defines the movement in between the windup and the hit frames. Changing the breakdown can drastically change what the animation would do, as shown in Figures 3.1 and 3.2.

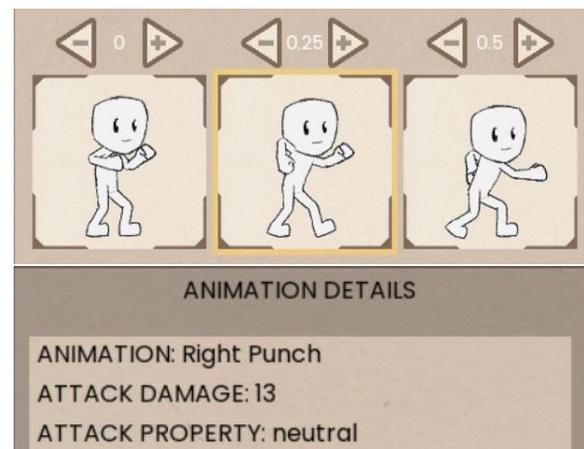
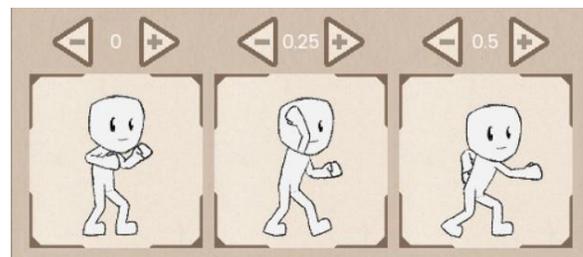


Figure 3.1: Breakdown that Makes a Neutral Attack



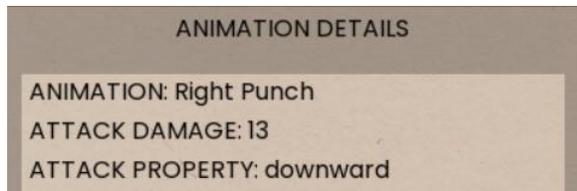


Figure 3.2: Breakdown that Makes a Downward Attack

Finally, the animation system has an effects system wherein the player can add an effect per keyframe (Figure 4.1). For example, by adding the squash and stretch effect on the keyframes of the jump animation, not only will it visually change the animation, it will also increase the jump height (Figure 4.2). A screen shake effect can also be added to the hit frame of a combat animation that visually shakes the screen and increases the damage output of an attack.

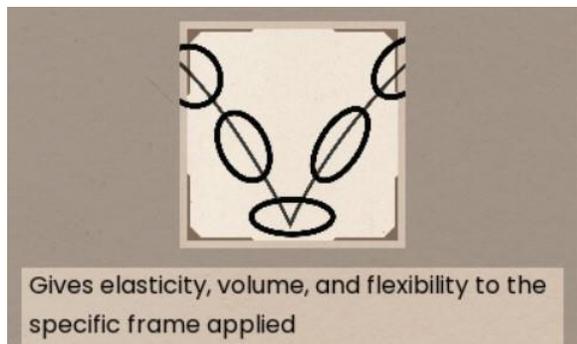


Figure 4.1: Squash and Stretch Effect

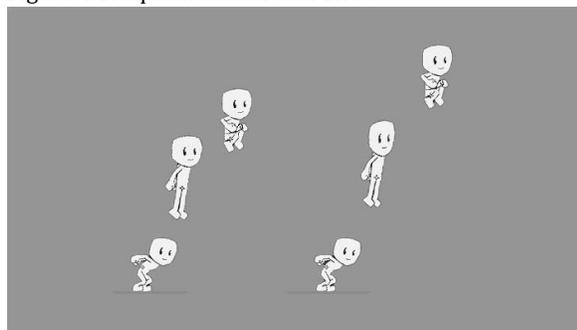


Figure 4.2: Squash and Stretch on the Jump Animation

### 4.2.1 Exploration

The game is a 2D platformer/metroidvania that requires the animation system for traversal. The player will be given several keyframes that will improve on their ability to traverse throughout the game’s world. The player starts by making a walk animation that allows the character to move left and right, but until the player gets the jump animation, the character won’t be able to get over short ledges.

The player is also given the ability to change the background of the world in order to change the conditions of the foreground. This allows the player to make progress in the exploration of the world. For example, changing the

background to winter in order to freeze water, as shown in Figures 5.1 and 5.2.



Figure 5.1: Regular Background



Figure 5.2: Winter Background

### 4.1.3 Combat

The combat system uses four attack buttons corresponding to each of the four attacks of the player character. It uses a timer based system where the player is only able to attack once a timer is finished. To prevent the player from using the same two moves consecutively, the last attack used is locked out until the player uses a different attack. The enemies also operate on the same timer system where they can only attack once their timer has finished.

Some enemies have resistances to certain attack properties. These resistances greatly decrease the damage an enemy takes from the attacks. However, the enemy can also have weaknesses to certain attack properties. An enemy hit with an attack they are weak against would put them in a stun state (Figure 6.1). After recovering from a stun state, the enemy will have the armor status condition that indicates that they will resist the weakness for a short period of time (Figure 6.2).

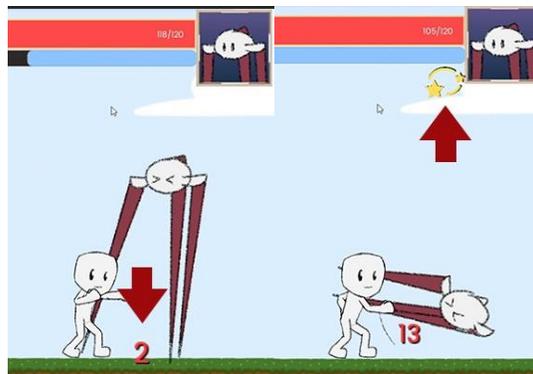


Figure 6.1: Enemy Resistance and Weakness

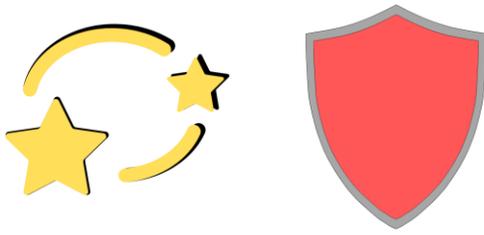


Figure 6.2: Stun and Armor Status Conditions

The player can customize their combat playstyle through the animation system. They can make the character fast but weak, slow and strong, or anything in between by changing the timing of their animations. The player can also target specific enemy weaknesses by changing the breakdowns used in their attack animations to change the attack properties.

## 4.2 Playtest Results

The playtest was conducted in two waves, mostly to find bugs in the game and fix them as soon as possible in the second wave. The second playtest was also conducted with the help of the feedback from the first wave of playtesters, as the researchers modified the game to improve the players' in-game experience according to the advice gathered in the first wave. The following sections combine the results of both waves of the playtest.

### 4.2.1 Testing Parameters

All chosen playtesters were 18 years old and above. Every playtester was given the same pre-test questionnaire for the researchers to categorize them into Category 1 and Category 2 testers. The playtesters who scored 80% and above in the Animation Concept Familiarity Scale portion of the pre-test questionnaire were grouped into Category 2 testers while the rest were grouped into Category 1 testers.

After the playtesters finished the game demo, they were given a post-test questionnaire depending on their tester category. Category 1 testers received a post-test questionnaire with an identical Familiarity Scale to the one in the pre-test questionnaire. In lieu of this, Category 2 testers had a question regarding the educational aspect of the game. Both questionnaires had questions pertaining to their thoughts on the game as entertainment and a Game Experience Questionnaire. Seven playtesters were able to accomplish their respective post-test questionnaires. Six from Category 1, and one from Category 2.

### 4.2.2 Player Feedback

**4.2.2.1 Game Mechanics and Entertainment Value.** Overall, 12 out of 13 playtesters found the game generally enjoyable. Similarly, 12 playtesters found the combat animation system to be the most enjoyable aspect of the game. They highlight the

breakdowns, effects, and animation timing systems in their responses.

The first wave playtesters criticized the UI navigation and the game's tutorials, particularly the spacing of these and the volume of the information given to them at a time, which was addressed in the second wave of playtesting. Some second wave playtesters found the counter-hit mechanic and the checkpoint setting when defeated to be problematic.

The playtesters' experience with the game was further detailed in the Game Experience Questionnaire. Generally, the playtesters found the game to be a positive experience, however challenging.

The following figures are the tabulated results of the Game Experience Questionnaire.

Figure 7.1 shows the responses to the Positive Experience Statements which contain statements like "I thought it was fun" and "I felt happy." The more the playtesters agree, the more they had a positive experience playing the game.

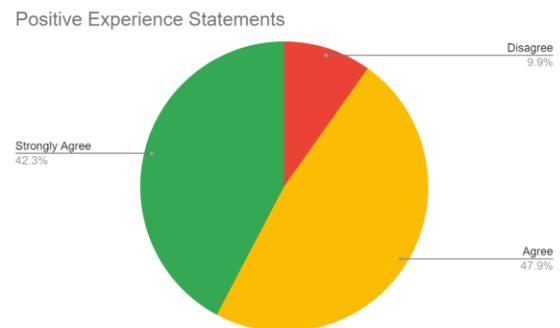


Figure 7.1: Positive Experience Statements

Figure 7.2 shows the responses to the Negative Experience Statements which contain statements like "I felt annoyed" and "It gave me a bad mood." The more the playtesters agreed, the more they had a negative experience playing the game.

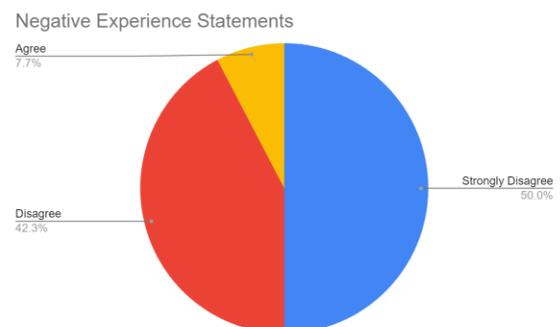


Figure 7.2: Negative Experience Statements

Figure 7.3 shows the responses to the Positive-Leaning Challenging Experience Statements which contain statements like "I felt competent" and "I felt successful." These statements

pertain to the difficulty of the game and how positive the playtesters found it to be.



Figure 7.3: Positive-Leaning Challenging Experience Statements

Figure 7.4 shows the responses to the Negative-Leaning Challenging Experience Statements which contain statements like “I felt frustrated” and “I felt time pressure.” These statements pertain to the difficulty of the game in a negative way.



Figure 7.4: Negative-Leaning Challenging Experience Statements

**4.2.2.2 Educational Aspect.** On the game’s educational value, the researchers asked the two Category 2 testers to share their thoughts on the game’s ability to present animation concepts effectively. The first tester said that the keyframe arrangement done in the animation system could be clearer, e.g. the follow-through frames in attacks are not distinguishable enough to be easily identified as follow-through frames. They also commented that the animation system would be more informative if the keyframes were not already arranged on collection since the player would have more incentive in reading the keyframe descriptions to see how each keyframe fits in an animation. The second tester found the game effective in presenting animation to beginners.

On the other hand, the researchers gauged the learning of the Category 1 testers by comparing their post-test scores with

their pre-test scores. All of the Category 1 testers had at least a 7% increase in their scores, with one of them having a 50% increase. The average increase of the Category 1 testers’ scores across both waves was 17.90%.

The following table details and compares the Category 1 testers’ pre- and post-test results.

	CAT1		
	OVERALL PRETEST SCORE	OVERALL POSTTEST SCORE	PERCENTAGE INCREASE
	40	47	10.94%
	48	61	20.31%
	22	32	15.63%
	16	48	50.00%
	34	41	10.94%
	40	47	10.94%
	49	48	-1.56%
	39	58	29.69%
	35	56	32.81%
	39	44	7.81%
	47	53	9.38%
<b>AVERAGE</b>	37.18	48.64	17.90%

Table 1: Category 1 Pre-Test and Post-Test Comparison

## 5 Conclusion

### 5.1 Effectivity of the Game in Introducing Animation

The video game was effective in introducing animation to its playtesters. They learned how to arrange keyframes into meaningful animations from the game’s animation menu. From this menu, although not explicitly stated in-game, they also learned about the principles of squash and stretch, anticipation, follow through, timing, and arcs.

Overall, the researchers believe that this game can be built upon with more features that can showcase even more principles of animation, more effects, more scenarios that can be used as a medium to educate players about the animation process, and the significance of different elements in these animations to the overall and final result of the animation. The animation system in the game is a good foray into the animation process since it mimics the style of a traditional animating/art application and includes the fundamentals of how moving pictures come to life.

### 5.2 Entertainment Value of the Game

Although focused on introducing animation to its players, the playtesters also found the game to be entertaining and fun. The combat aspect, combined with arranging their own animations for traversing the world and fighting enemies is what made up most of the entertainment value of the game.

### 5.3 Issues

The game was plagued with multiple bugs and exploits that broke the game, making it unplayable or adding too much of a hassle for a player and preventing them from enjoying the game. Most of the issues encountered were experienced by the first wave of playtesters, with bugs including being stuck in a menu, characters falling out of the map, and the animation system being heavily exploited because of the degree of freedom given to the players to make their own animations. Players were able to put in frames in the traversal animations that don't necessarily belong to those specific movements, and give them a really high jump height, or high movement speed.

Additionally, as the game is educational and introductory, there were many foreign mechanics that were explained to the players in tutorials which were shown in heavy amounts in too small of a timeframe. These tutorials were spread out, however, these were still very heavy in content as a lot of mechanics in the game were significantly different from other, more popular games and game genres.

### 5.4 Recommendations

The concept of arranging your own movement and attack animations, and deliberately designing them to fit your own strategy has a really high potential in formulating a very enjoyable and detailed gameplay experience. From the findings and limitations encountered during the development and testing period, the researchers propose:

- Building other gameplay mechanics that take advantage of the animation system design
- Adding other elements and effects of animations that cover the remaining principles of animation that were not tackled in the final prototype of In-Between Frames: An Animation Adventure.
- Formulate better plot and lore to deepen the players' interest in the game
- Put more emphasis on the animation system, as it is the fundamental system that is utilized by all of the game's mechanics

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