Can You Spot The Difference?

Learning About Different Greek Art Periods Through Serious Games.

Thesis Presented by

Sai Krishna Prasad Korivi

to

The College of Arts, Media, and Design

As a partial fulfillment of the criterion for the Degree of Master of Science in Game Science and Design

Northeastern University

Boston, Massachusetts

December, 2022

Table of Contents

Acknowledgement

I want to thank all the friends and mentors who have helped me with and supported this thesis. I want to start by sincerely thanking Giovanni Troiano, my adviser, for his support, inspiration, and guidance in helping me finish this research project. I want to express my deep gratitude to Tejashree Korivi for helping me get in touch with so many volunteers for my study. Finally, I'd like to express my gratitude to all of my participants for volunteering their time.

Abstract

In serious games, the goal is not entertainment but to improve players' understanding and knowledge. Unlike games-based learning, a serious game player must understand the message of the game, while in games-based learning, players learn regardless of how they play. To ensure players understand their message, serious game creators must keep them engaged throughout the game.

Sadly, serious game creators are only interested in how their message can be conveyed, often overlooking the factors that engage players. This thesis examines whether adding challenges from the entertainment game genre to the serious game design can enhance the players' engagement while creating a positive path for learning the message through serious games. And to answer this research question, I focused my thesis on a self-designed serious game that imparts subject knowledge to players, namely ancient Greek art periods. As a result of this game, I measure the player's learning outcomes and gameplay experience to investigate if serious game creators can improve player engagement with the aid of entertainment games.

Keywords

Serious games, Game-based learning, Entertainment games, Player engagement, Challenges, Player Experience Inventory, Greek Art Periods.

1. **INTRODUCTION**

Many different contexts are currently employing video games [1], one of which is educational learning games, which appear to have an immense potential. These games are often called serious games and can be used to teach subjects as diverse as arithmetic, engineering, and science. While most serious games aim to promote learning, their lack of engagement often prevents them from doing so. This thesis aims to examine how we may improve players' engagement in learning through serious games from the standpoint of the serious game creator. My study analyzes how introducing or eliminating an entertainment game challenge element can enhance a player's sense of engagement while playing a serious game. In my argument, I discuss how serious video games can be played like casual games while still imparting knowledge about a particular subject to players. To accomplish this, I developed a straightforward archaeology serious game. By solving simple challenges, players can unlock the path to the next era by learning about the four Greek art periods of antiquity. Moreover, it determines whether changing the overall difficulty of the level can enhance the player's learning. There will be two versions of the same game. One resembles game-based learning for entertainment, while the other is more devoid of challenging components and resembles a serious educational game. A major goal in the serious game is to learn about the four Greek art periods of antiquity by following the narrator non-player character (NPC) [2]. Another requires you to complete more complex challenges with time complex that make it a little more challenging than a serious game. I’m trying to create flow and immersive experiences through difficulty in games [3]. And will track both the amount of learning and the player engagement from each experience to determine which players like the best. If players prefer the challenging version and still learn about the four Greek art periods, the result will be noteworthy. And we can argue that serious game creators should not be afraid to add additional features to their games to prevent them from becoming boring and increase player engagement while creating a positive path for better learning outcomes.

2. BACKGROUND

2.1 Serious games

2.1.1 Definition

The term "serious game" refers to a game whose primary purpose is not for pure entertainment [4]. The "serious" part of the label refers to the fact that these games are typically used for more educational or informational purposes, unlike traditional video games designed purely for entertainment value. The primary focus of serious games is training, education, health, and safety. While they can be informative, they lack in achieving challenge element from entertainment games, resulting in less engagement and effectiveness in achieving their goals.

2.1.2 Serious games vs. Entertainment games

Entertainment games are designed to entertain the player. They typically have a competitive element and focus mainly on providing a fun and enjoyable experience. Many entertainment games are also educational, teaching the player about a particular topic or helping them to develop a new skill. These games are branded and sold based on brand recognition, graphical realism, and gameplay attributes. Still, they are ultimately designed for the player's enjoyment.

Serious games' ultimate purpose is to create a lasting effect on the players. They are designed with specific objectives, like doing research or teaching the player useful skills. The major purpose of serious games should be to convey the necessary information and results through the proper channels and at specific moments.

2.1.3 Serious games vs. Games-Based learning

Games-based learning is a type of educational game that is designed to teach players specific skills or knowledge. Games-based learning can be used in a variety of settings, including classrooms, after-school programs, and informal learning environments.

These games are different from serious games because they are not intended to be used for entertainment or purely fun. Instead, games-based learning is meant to be an instructional tool that can help players learn new information or improve their skills. [5]

2.2 History of serious games

The term Serious Games can be traced to the seminal work of Clark Abt [6]. The first serious game, SimHealth, was released in 1992 by Maxis. SimHealth was developed to educate players about the complexities of the U.S. healthcare system. They designed this game to be an interactive teaching tool that used a simulated game world to allow players to make decisions and see the consequences of their choices.

Since then, serious games have become increasingly popular. In the 2000s, games were developed for various educational, training, and awareness purposes. In the 2010s, serious games became even more widespread and have been used for multiple purposes. Serious games educate, train, and inform people in healthcare, education, business, and entertainment. We use serious games to increase public awareness of social issues such as climate change and to promote healthy

lifestyles. We also use serious games to help people with special needs, such as autism and Alzheimer's.

Today, the development of serious games aims for a variety of purposes. As technology advances, serious games are becoming increasingly sophisticated and used to solve more complex problems.

2.3 Types of serious games

Under their structure and purpose, all serious games can be divided into process-oriented and outcome-oriented games. [7]

Process-oriented games emphasize exploration over completion. We see the essential learning value in the player's decision-making process throughout the encounter. For the aims of research, decision-making, and simulation, process-oriented games are the most successful.

Outcome-oriented games require the player to perform actions to achieve a specified goal. All gaming activities revolve around achieving a goal, which is usually ability in a skill or the performance of an activity. The most effective educational, persuasive, and motivational games are outcome oriented.

3. METHODOLOGY

3.1 Game design & Development

3.1.1 Overview

With extrinsic [8] challenges inherent in entertainment game design, this study attempts to build a serious interactive game that allows learners to feel involved in the game environment. We propose "Ancient Greek Art Periods," a first-person role-playing game [16] for our research. Players assume the character of Alex, a candidate for the associate conservator position at the museum. They must follow and carry out the tasks and instructions given by the NPC instructor, Ava, the current conservator of Greek artifacts at the museum, to progress in the game. The proposed game is published on an open marketplace for independent games for players to access. Figure 1 shows a screen capture of a player navigating through one of the Greek art periods (Classical Era) in the gameplay scene.

Figure 1

Making the game engaging and informative at the same time is our top priority. And to accomplish this, separate phases of the learning objectives are divided up

by museum rooms. We use multimedia learning principles to create an interesting and worthwhile game. I design instructional content guided by multimodal learning principles to supply effective instructional material that improves users' knowledge acquisition and increases engagement [9]. Before the game's creation, I laid out all objectives, player actions, obstacles, prizes, guidelines, criticism, and interactions following multimedia principles.

3.1.2 Design process

3.1.2.1 Breakdown of the gameplay

The main goal of "Ancient Greek Art Periods" is for players to navigate the virtual museum environment and perform the missions to progress through the level and learn about the many periods of Greek art history. To achieve this goal, players must follow Ava's (NPC guide) instructions, examine the various artifacts in a room to spot essential characteristics that distinguish these relics from other art period relics, and complete the missions to open doors that allow them to enter and learn about the next art period. Two versions of the video game "Ancient Greek art periods" have been created and released for this study. These variations aim to examine the differences in player engagement when challenge aspects from entertainment games are incorporated into serious games.

Both games are simple archaeological serious games in which players must find and select a relic from a specific Greek art period out of a pool of relics from other Greek art periods. The only change between the two games is that we added double the number of relics to the pool of relics for players to choose from and a timer that keeps depreciating on game progression as extra game challenges in the experimental game for this study. Players can view controls from the control panel at the menu scene of the game. At the start of the game, we collect the players' names. And before players enter the virtual environment, supply a first quiz to assess their understanding of the Greek art periods. And the same quiz is given to both game participants after they finish the game to see how much knowledge they

have obtained from playing the game. On completion of the game, I direct the participants to a survey in which I expect them to rate several PXI constructs [10] in this game using a Likert scale. I will go over each game scene in depth below.

3.1.2.2 Pre- and Post-Quiz scene

This scene's main purpose is to help us measure how well the learner understands the subject of Greek art periods before and after playing the game. With increased familiarity with the game's subject, players can go on to the next level more easily. When a player is ready, they can advance to the next level.

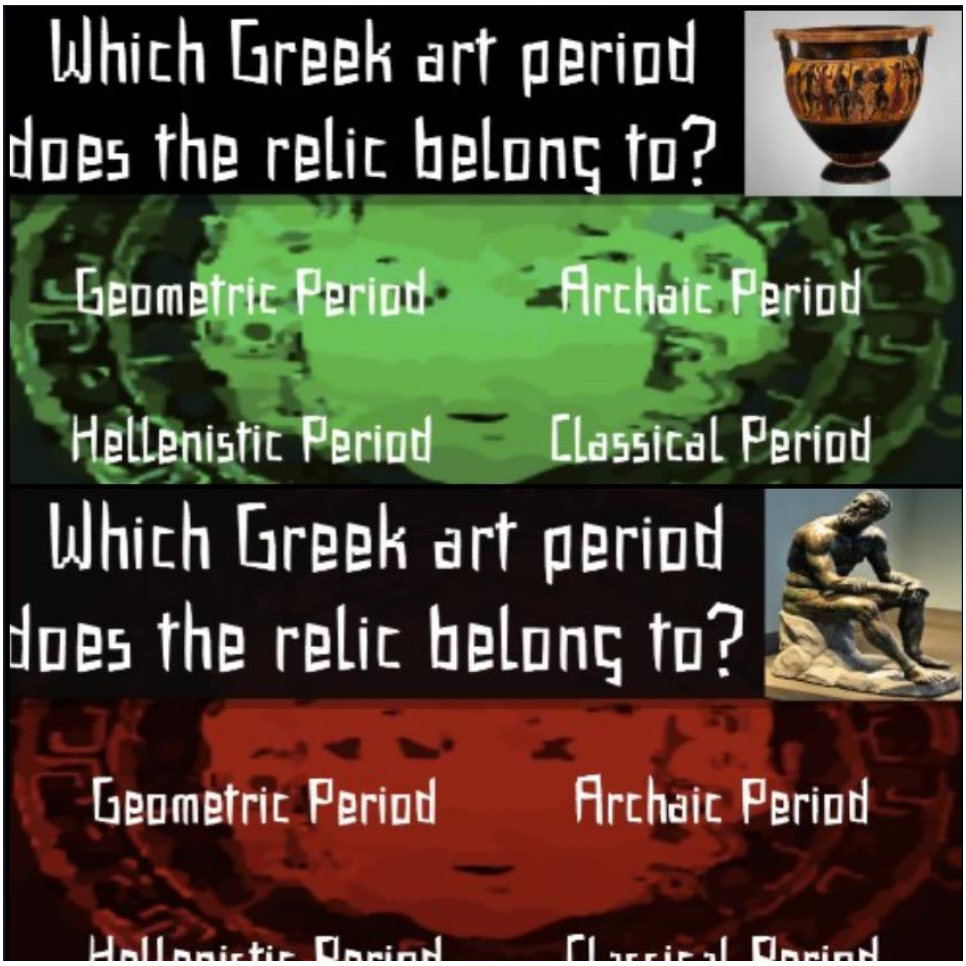
A) Pre-game quiz scene:

I asked the participants eight multiple-choice questions about ancient Greek art periods in this game scene. I use this scene to figure out how well the players understand the subject and as the preliminary test results in data for measuring the players' learning outcomes. Four of the eight questions ask players to select the Greek period to which the shown image of the artifact belongs. The remaining four questions ask the participants to find distinguishing aspects of the four Greek art periods. Textual feedback is displayed on the screen to present the players' performance on the quiz, including a score. Figures (2 & 3) depict the two types of questions from the quiz game scene.

Figures 2: Which Greek period has the mentioned distinguishable feature?

B) Post-game quiz scene:

This scene follows the gameplay scene and is identical in substance and style to the Pre-game quiz scene. The goal of including this scene after gameplay is to figure out if there is a change in the players' learning outcomes and, if so, whether it has a beneficial or detrimental impact on the players' learning outcomes.



Figures 3: Choose which Greek period does the artifact belong to?

3.1.2.3 Gameplay scene

A) Control group scene:

The players explore the many Greek art periods while completing simple tasks to advance to the next period in the Greek art timeline by selecting the correct artifact in each room. As a result, they must understand and pay attention to everything within each room to find the artifact. This scene has no other challenges.

Players take on the role of an applicant for the position of associate conservator at the museum. To learn about the various Greek art period artifacts in the scene and how each period differs from other periods, they communicate with Ava (an NPC), the current museum conservator.

Moreover, I designed an interactive dialogue system to present pre-made conversational data to aid players in learning about the four ancient Greek art periods while adhering to multimedia learning principles to supply an engaging experience.

Players can also learn about a specific Greek art period by interacting with virtual game artifacts. When the player approaches each artifact in the scene, a unique message displays on their HUD. This message has key information about the different distinguishable factors among the four ancient Greek art periods.

Figures 4: Control group task to progress from Geometric era to Archaic era.

B) Experimental group scene:

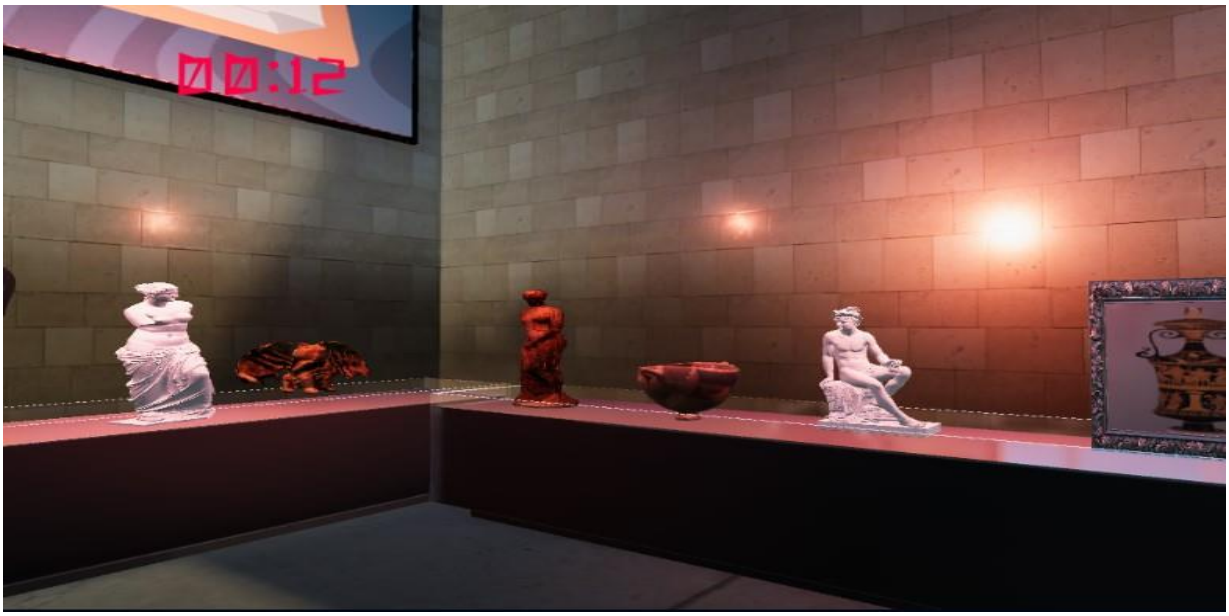
The players must choose the right artifact from a pool of two times as many artifacts as the players in the control group scene had to move on to the next period in the timeline of Greek art periods. A timer that counts down every time the players must finish a task

adds to the complexity of the time challenge. As the levels progress, this timer gets shorter. Players must therefore understand each room's contents and pay close attention to every detail to find the relic. This scene will feel much more difficult and engages players to pay close attention than the control scene.

Like the control group scene, players assume the character of an applicant for the post of an associate conservator at the museum. They speak with Ava (an NPC), the current museum conservator, to learn more about the many Greek art period artifacts in the scene and how each art period differs from another.

Additionally, like the control group game, I create a dialogue system to offer pre-made conversational facts while following multimedia learning principles to create an engaging experience for players to learn about the four ancient Greek art periods.

Players can also learn about a particular Greek art era by engaging with virtual game artifacts. The HUD displays a different prompt when the player approaches each artifact in the scene.



Figures 5: Experimental group participants task to progress from Geometric era to Archaic era.

3.1.2.4 End game scene

Both games' concluding scenes will drive players to a survey form where they can rate their overall satisfaction using various PXI constructs. When players click the "Quit" button, I direct them to the survey for their respective groups.

Figures 5: Connecting post-game survey google form for testing player experience.

3.2 Research Design and Protocol

3.2.1 Research Design

The purpose of my research is to discover how players' engagement and learning outcomes are affected by the inclusion of particular entertainment gaming elements in serious games. I divided the participants into control and experimental groups for this study, each with a separate set of individuals. I will ask all participants from both groups to complete a pre-playtesting consent form. Participants in the control group will play a serious game with no entertainment game components to set the base readings for my study. And the experimental group participants will play a serious game with elements of an entertainment game to supply the required data to test for my research question.

I will empirically explore how players experience and learn from the game through the lens of the PXI, which is built on ten constructs (meaning, mastery, [10].). I employ post-semi-structured surveys for qualitative analysis to assess player engagement in both the control and experimental groups. Furthermore, for this quantitative research, I use the mini–Player Experience Inventory (mPXI) [11] post-surveys [12] with a Likert scale [13] to assess whether playing a serious game with or without entertainment elements is beneficial for the player's learning outcome. In addition, we use an independent t-test on the means of the gathered data to see if there is a significant difference between selected PXI constructs and learning outcomes when participants play the control and experimental games.

3.2.2 Research Question

Can we adopt certain entertainment game elements to aid serious games in avoiding boredom and alienating their players while simultaneously improving learning outcomes?

3.2.3 Research Hypothesis

We study our research topic with the help of two games made specifically for this study, "Ancient Greek Art Periods - Serious & Entertainment." To answer our research question, we separate our study into the following two parts (a) and (b):

(a) The first part of our study examines the players' learning results concerning the increase in game difficulty.

Hypotheses:

Null Hypothesis (A0): The learning outcomes of players will not be affected by the change in the serious game.

Alternate Hypothesis (A1): The learning outcomes of players are positively affected by the change in the serious game.

(b) The players' engagement with the changes made to the game's difficulty is the focus of our study's second part.

Hypotheses:

Null Hypothesis (B0): The player's engagement is not affected by the change in serious games.
Alternate Hypothesis (B1): The player's engagement is positively affected by the change in the serious game.

3.2.4 Research Participants

An online study with over thirty participants aged between 19 and 39 was used to conduct the research. I ask the participants to playtest the game before filling out the survey form. Any participant has the right to stop and leave the investigation at any time during the experiment. Before playing the game, I checked participants for their understanding of the study subject (Greek Art Periods). To obtain exact readings, I needed to ensure that none of the participants in either group previously knew about the subject, as this would result in data redundancy.

The participants in this experiment included 24 males and 8 females. I randomly assigned the participants to one of two game versions, with 15 participants in the control group and 17 individuals in the experimental group.

3.2.5 Research Measures

The division of player experiences helps organize player data for this study. Since the player experience is a dependent variable in this experiment, the Player

Experience Inventory table (Table 1) facilitates more accurate measurement of player feedback. The dependent variables I measure which relate to player engagement for this experiment include immersion, curiosity, and challenge from the player experience inventory.

Table 1. Player Experience Inventory (PXI)

Item	**Construct**	**Statements**
1	Meaning	Playing the game was meaningful to me.
2	Mastery	I felt I was good at playing the game.
3	***Immersion***	I was fully focused on the game.
4	Autonomy	I felt free to play the game in my own way.
5	***Curiosity***	I wanted to explore how the game evolved.
6	Ease of Control	I thought the game was easy to control.
7	***Challenge***	The challenges in the game were at the right level of difficulty for me.
8	Progress Feedback	The game informed me of my progress in the game.

9	Audio Visual Appeal	I liked the look and feel of the game.
10	Goals and Rules	The goals of the game were clear to me.

4. RESULTS

The experiment primarily examines how adding entertainment game elements to a serious game affects the participants' learning outcomes and their own game experience. This section will mostly introduce the findings of the experiments. In addition, I will briefly explain the data from the learning outcomes and player experience in the t-test results.

Please see [Appendix A] for more information on the data collection methods used in my experiment.

I use the t-test (statistical test) to compare the means of our sample populations and see if there is a significant difference. The t-test yields a 't' value, which helps us calculate the p-value. The p-value expresses the likelihood that 't' falls within a given range. In other words, this is the value you use to determine whether the difference in means between your sample populations is significant. A p-value of 0.05 indicates a significant difference between the means of our sample population, and we would reject the null hypothesis. A p-value greater than 0.05 writes down no significant difference in the means of our sample populations, and we would not reject our null hypothesis. Two types of t-tests are unpaired and paired t-tests.

- Unpaired t-test: We use this type of t-test when the samples are independent.
- Paired t-test: When our samples relate, we can use this t-test.

Because my study has independent samples, I will use unpaired t-tests [14], and the best type of test in RStudio is the Welch 2-sample t-test [15]. Because this test does not require the two groups to have the same variance. Unless we have reliable advanced knowledge that the two populations have essentially the same variance, it is considered good statistical practice always to use the Welch 2-sample t-test rather than the pooled test. The Welch test is the 'default' test in R and many other statistical software programs.

4.1 Learning Outcomes

Data analysis to figure out whether the two participant groups' "Learning Outcomes" differ:

```
#HYPOTHESIS----------------X

#Null Hypthesis: There is no significant difference in learning outcomes / quiz data in both participant groups.
# p > .05

#Alternative Hypothesis: There will be a significant difference in learning outcomes / quizdata in both participant groups.
# p < .05


# Welch 2-sample t test between Pre-Quiz scores of control and experimental group.
t.test(data_1$Cntrl_Q1,data_1$Exp_Q1, var.equal = FALSE)

# Welch 2-sample t test between Post-Quiz scores of control and experimental groups.
t.test(data_1$Cntrl_Q2, data_1$Exp_Q2, data = data_1 , var.equal = FALSE)
```

I reorganized pre- and post-quiz data in an Excel Workbook for easier interpretation in RStudio.

Rearranging_LearningOutcomes_QuizD

We conducted a two-tailed independent t-test for the Likert scale on our data. I also set the significance level at 0.05. According to the null hypothesis, player learning outcomes are unaffected by changes to the serious game. The opposing perspective also asserts that modifications to the serious game impact players' ability to learn.

For significance, I examined the difference between participant groups' pre- and post-game quiz scores. The image below shows the results of the t-test between the learning outcomes data from the experimental group and the control group. From this, we can observe that there is no significant difference between the participants in the pre-quiz since the p-value is greater than 0.05. However, there is a considerable difference in post-quiz scores because the p-value is negative and less than 0.05. This result suggests that our alternate theory is correct.

Pre-Quiz

```
> t.test(data_1$Cntrl_Q1,data_1$Exp_Q1, var.equal = FALSE)

        Welch Two Sample t-test

data:  data_1$Cntrl_Q1 and data_1$Exp_Q1
t = 0.61237, df = 27.858, p-value = 0.5453
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.4691608  0.8691608
sample estimates:
mean of x mean of y
      1.2       1.0
```

Post-Quiz

```
> t.test(data_1$Cntrl_Q2, data_1$Exp_Q2, data = data_1 , var.equal = FALSE)

        Welch Two Sample t-test

data:  data_1$Cntrl_Q2 and data_1$Exp_Q2
t = -7.1965, df = 27.17, p-value = 9.35e-08
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -3.940759 -2.192574
sample estimates:
mean of x mean of y
 3.800000  6.866667
```

I also use boxplots to visually illustrate the change in quiz scores, with participant groups on the X-axis and quiz scores on the Y-axis.

- Groups of Participants:

  A - Participants in the control group

  B - Participants of the experimental group

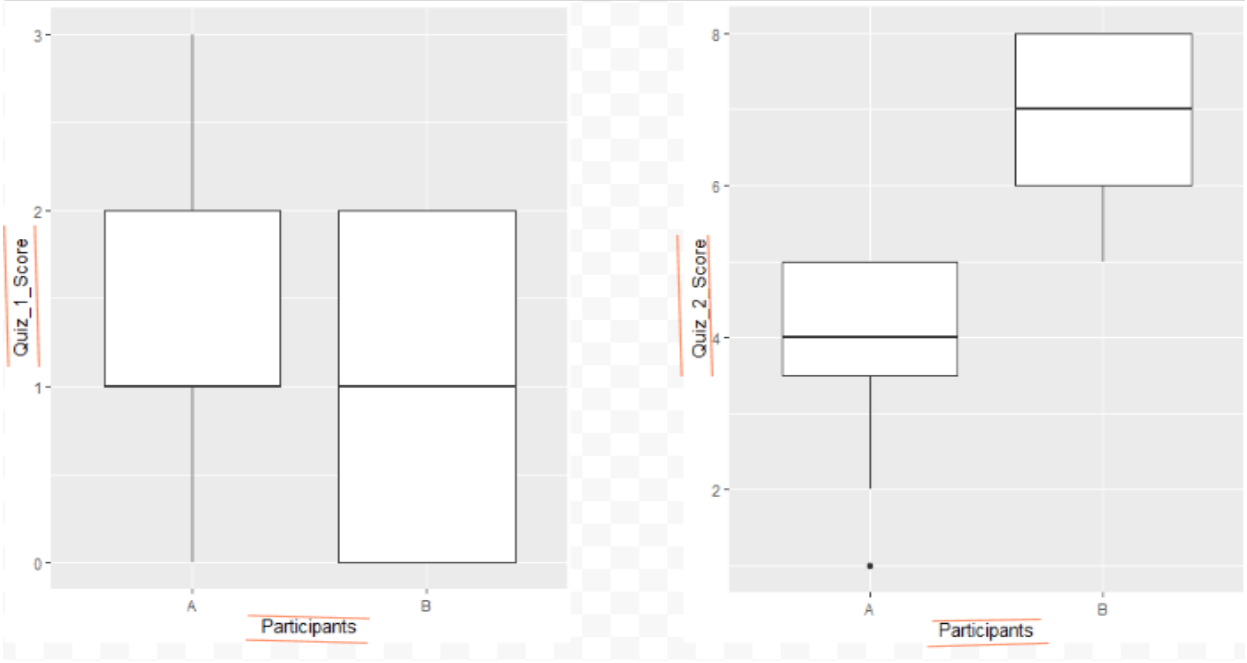
- Scale of Quiz Scores: Each quiz had a total of eight questions, allowing participants to score anywhere between 0 to 8 for correct responses.

```r
#Data for testing the Significant Difference----------------X

#Reading rearranged 'Game quiz data' xls file.
data_1 <- read_excel("QuizData.xlsx")

#Boxplotting Quiz 1 and Quiz 2 scores w.r.t participant data.

#Participant vs. Pre-quiz data
ggplot(data_1, aes(x=Participants, y=Quiz_1_Score))+geom_boxplot()
#Participant vs. Post-quiz data
ggplot(data_1, aes(x=Participants, y=Quiz_2_Score))+geom_boxplot()
```



4.2 Player Engagement

Data analysis to determine if there is a difference in 'Player Engagement' between the two participant groups:

I examined three primary constructs from the PXI construct data acquired by participants via an mPXI survey at the end of playtime to test player engagement through our games. The three tested constructs are as follows:

A. Immersion
B. Curiosity
C. Challenge

```
#Research Question Part 2----------------X

#Null Hypthesis: There is no significant difference in player engagement construct in both participant groups.
# p > .05

#Alternative Hypothesis: There will be a significant difference in player engagement construct in both participant groups.
# p < .05

#Reading rearranged 'Player experience survey data' xls file.
data_2 <- read_excel("mPxiData.xlsx")
```

Once more, I rearranged the Likert scale data into an Excel Workbook for ease of interpretation in RStudio.

Rearranging_PXI_data_for_Rscript.xlsx

We run an independent t-test for the Likert scale with two-tailed hypotheses on our data. The null hypothesis states that changes to the serious game do not affect the player's engagement. Furthermore, the alternative viewpoint holds that changes to the serious game affect the player's engagement. We also set the significance level to 0.05.

T-test results between the specific PXI constructs data from the control and experimental group are as follows:

```
# Welch 2-sample t test between different PXI constructs of control and experimental groups.
t.test(data_2$Control_Immersion,data_2$Experimental_Immersion, var.equal = FALSE)
t.test(data_2$Control_Curiosity,data_2$Experimental_Curiosity, var.equal = FALSE)
t.test(data_2$Control_Challenge,data_2$Experimental_Challenge, var.equal = FALSE)
```

Immersion

```
        Welch Two Sample t-test

data:  data_2$Control_Immersion and data_2$Experimental
_Immersion
t = 12.055, df = 24.485, p-value = 8.659e-12
alternative hypothesis: true difference in means is not
 equal to 0
95 percent confidence interval:
 2.190853 3.094861
sample estimates:
mean of x mean of y
 4.142857  1.500000
```

Curiosity

```
        Welch Two Sample t-test

data:  data_2$Control_Curiosity and data_2$Experimental
_Curiosity
t = -9.4402, df = 27.558, p-value = 3.946e-10
alternative hypothesis: true difference in means is not
 equal to 0
95 percent confidence interval:
 -1.901788 -1.223212
sample estimates:
mean of x mean of y
   3.0000    4.5625
```

Challenge

```
        Welch Two Sample t-test

data:  data_2$Control_Challenge and data_2$Experimental
_Challenge
t = -6.5202, df = 27.8, p-value = 4.728e-07
alternative hypothesis: true difference in means is not
 equal to 0
95 percent confidence interval:
 -2.910163 -1.518408
sample estimates:
mean of x mean of y
 2.285714  4.500000
```

I also use boxplots to visually illustrate the change in quiz scores, with participant groups on the X-axis and the Likert scale range on the Y-axis.

- Groups of Participants:

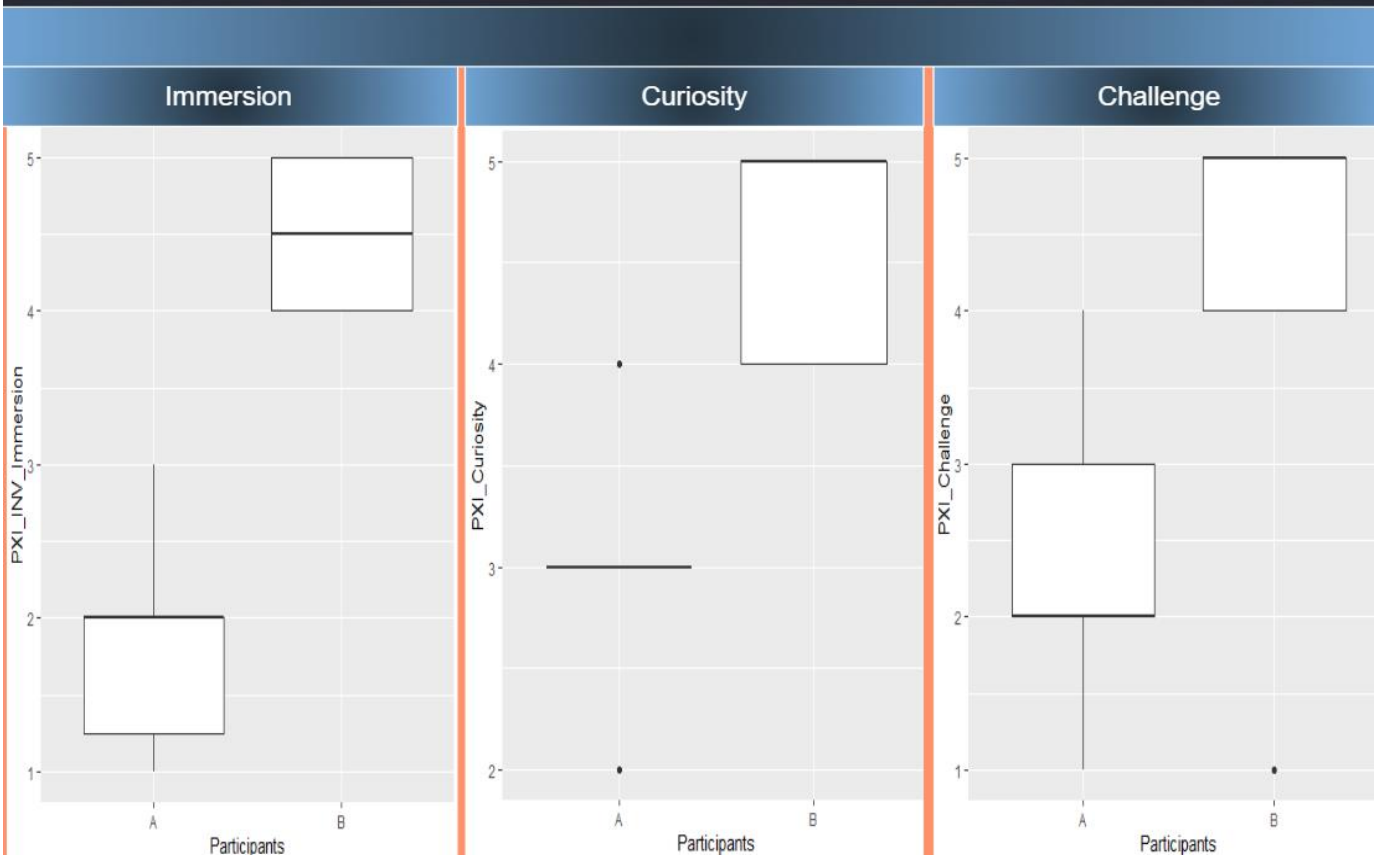
A - Participants in the control group

B - Participants of the experimental group

- PXI components are scaled using a Likert scale. For each survey question, participants received a choice of five options. We employ a linear scale in this scale, ranging from '5' - Strongly Agree to '1' - Strongly Disagree.

```
#Boxplotting PXI constructs w.r.t participant data.

ggplot(data_2, aes(x=Participants, y=PXI_INV_Immersion))+geom_boxplot()
ggplot(data_2, aes(x=Participants, y=PXI_Curiosity))+geom_boxplot()
ggplot(data_2, aes(x=Participants, y=PXI_Challenge))+geom_boxplot()
```



5. Discussion

We will discuss the experimental findings based on this time's testing results, including the impact and effect of other challenging game elements on the player, the potential of serious games when they can more effectively engage players, and the experiment's limitations.

5.1 Impact of Player engagement on Learning outcomes in Serious Games

The experiment revealed that participants paid closer attention when they had to overcome new obstacles to advance in the serious game. As a result, using entertainment game elements improved their engagement and learning results. The variation in player engagement affects the learning outcomes when comparing several versions. In serious games, player engagement may figure out the learning outcomes.

And I will further discuss in future studies which need to be performed to get the best principles serious game creators can follow to design more engaging levels.

5.2 Limitations and Future Works

5.2.1 Measuring Player Engagement

We cannot stand all aspects of player engagement, even though players fall into a wide variety of categories, and everyone will have their preferences on game

selection. More components should be considered and measured in parallel for future research. Because each sort of player has a different favorite game genre and game aspects, I will update the game to include more gameplay along with other entertaining game elements like rewards and procedural content generation. Besides these factors, evaluating scene reality is also important.

5.2.2 Time period for gameplay

Since I designed this game using an MVP methodology, the gaming time is brief. The game, which has just one level, must be finished by the players once. To assess more accurately the effects of entertainment game elements on player engagement and learning outcomes in serious games, I can double the playtime time in future iterations.

6. CONCLUSION

This study looked at how serious games could use a challenging entertainment game aspect to increase player engagement. When I integrate certain entertainment game features into the level, the results prove that players are more engaged and have positive learning outcomes in the serious game. However, bringing entertainment game aspects to serious games requires further development because, aside from the difficulty element, I could only investigate some of the many entertainment game elements. As a result of the significant differences in learning outcomes between the two participant groups I created for this study, if I continue this research, I will investigate whether replayability affects learning outcomes in serious games in particular. Serious game designers who want to make engaging levels can use the strategies I used in this study as a reference.

References

1. Wikipedia contributors. “Video Game.” Wikipedia, December 8, 2022. https://en.wikipedia.org/wiki/Video_game.
2. Wikipedia contributors. “Non-Player Character.” Wikipedia, December 2, 2022. https://en.wikipedia.org/wiki/Non-player_character.
3. Juul, J.: Fear of failing? The many meanings of difficulty in video games. In: Wolf, M.J.P., Perron, B. (eds.) The Video Game Theory Reader 2, pp. 237–252. Routledge, New York (2009)
4. ———. “Serious Game.” Wikipedia, November 8, 2022. https://en.wikipedia.org/wiki/Serious_game.
5. Becker, K. "What’s the difference between gamification, serious games, educational games, and game-based learning." *Academia Letters* 209 (2021). link
6. Wilkinson, Phil. "A brief history of serious games." *Entertainment computing and serious games* (2016): 17-41. link
7. King, Nico. “Serious Games Guide: Everything You Need to Know in 2021.” Chaos Theory, August 24, 2022. https://www.chaostheorygames.com/blog/serious-games-guide-everything-you-need-to-know-in-2021.
8. Vriend, Sita. “Intrinsic and Extrinsic Motivation.” Game Developer, August 4, 2017. https://www.gamedeveloper.com/design/intrinsic-and-extrinsic-motivation.
9. Nogueira, Pedro A., Vasco Torres, Rui Rodrigues, Eugénio Oliveira, and Lennart E. Nacke. "Vanishing scares: biofeedback modulation of affective player experiences in a procedural horror game." *Journal on Multimodal User Interfaces* 10, no. 1 (2016): 31-62. **link**
10. Aqeel Haider, Kathrin Gerling, and Vero Vanden Abeele. 2020. The Player Experience Inventory Bench: Providing Games User Researchers Actionable Insight into Player Experiences. In *Extended Abstracts of the 2020 Annual Symposium on Computer-Human Interaction in Play (CHI PLAY '20)*. Association for Computing Machinery, New York, NY, USA, 248–252. DOI: https://doi.org/10.1145/3383668.3419898
11. Harteveld, Casper, Nithesh Javvaji, Tiago Machado, Yevgeniya V. Zastavker, Victoria Bennett, and Tarek Abdoun. “Preliminary Development and Evaluation of the Mini Player Experience Inventory (MPXI).” *Extended Abstracts of the 2020 Annual Symposium on Computer-Human Interaction in Play*, November 2, 2020. https://doi.org/10.1145/3383668.3419877.
12. Moyo, Lesley M. "Using a pre-and post-survey method to assess the effectiveness and usability of an online information literacy tutorial." (2011). link

13. Mcleod, Saul. “Likert Scale Definition, Examples and Analysis - Simply Psychology,” 2008. https://www.simplypsychology.org/likert-scale.html.

14. “Unpaired Two-Samples T-Test in R - Easy Guides - Wiki - STHDA,” n.d. http://www.sthda.com/english/wiki/unpaired-two-samples-t-test-in-r.

15. “T Test | Practical Applications of Statistics in the Social Sciences | University of Southampton,” n.d. https://www.southampton.ac.uk/passs/gcse_scores/bivariate_analysis/t_test.page.

16. ———. “Role-Playing Game.” Wikipedia, December 5, 2022. https://en.wikipedia.org/wiki/Role-playing_game.

Appendix A

A.1 Data Collection

A.1.1 Participant Consent Form Responses Record

The following consent link was supplied to all participants from both groups, authorizing the study's researcher to utilize their data in the investigation.

Consent Form Link: Link

The following is a list of participants who volunteered and gave us permission to use their personal data: Google Forms sheet

A.1.2 Method

I use Google forms to collect data for our quantitative analysis. Both our pre- and post-quiz scores data and the mPXI post-survey data collected from the participants are transmitted using the following links:

- Pre & post quiz score data forms:
    - Control group quiz scores – link
    - Experimental group quiz scores - link

- Player engagement data forms:
    - Control group mPXI data - link
    - Experimental group mPXI data - link

Furthermore, we structure the data as follows to calculate their mean and test our different hypotheses.

We obtain data for the two serious game groups (Control and Experimental groups) and collect participants' responses on the ten different PXI constructs to check if players in experimental group have a more engaging gameplay experience and improved learning outcomes when compared with the control group participants.

- Through Pre- and Post-Game Quiz Scores, we check for the learning outcome of participants in both groups.
    - In this quiz, we provide close-ended questions related to the four different Greek art periods (Ex: matching pictures of arts to their corresponding periods and one true/false question on each of the four periods).
- And through the Player experience section, we collect responses from participants on the different PXI constructs in both groups.
    - mPXI Questionnaire for the player experience of both groups.
    - We collect data for player engagement through mentioned post game surveys.