

CS449/549 - Human Computer Interaction

ASSIGNMENT 5: Group Assignment- User Based Usability Testing of Virtual Reality Environments

Group 11:

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1. Methodology

- a. Users:** The age range of the users is between 21 and 23. There are 3 females and 2 males among the users.

Name	User_id	Age	Gender	Profession	Department	Game experience	VR experience
Esma Günay	1	23	Female	Student	CS	Mid	No
Elif Berfu Evliya	2	21	Female	Student	VA	Mid	No
Emirhan Özdemir	3	23	Male	Student	CS	High	No
Pelinsu Saraç	4	21	Female	Student	CS	Low	No
Bařış Çukur	5	22	Male	Student	CS	High	No

Table 1: Personal information of users.

b. Test Procedure:

Before the test:

- A quiet and isolated environment was arranged.
- Researchers conducted a pilot test for level 1 and level 2 of the game.
- The phone is fixed to be put on the cardboard virtual reality glass.
- Users are informed about the instructions of the experiment, they are told to think out loud during the gameplay.
- The personal information related to users are collected.

- The researchers took the consent of the users for conducting the experiment and recording a video.
- Users sat on the swivel chair to make movements feasible.
- Users had 2 attempts for each level.

During the test:

- The users were recorded during gameplay to collect data on their interactions with the game.
- While the users were playing, the screen recording of the game was also captured for further analysis.
- Quantitative data (i.e., number of fails per level, number of crashes, etc.) was collected for each user during gameplay. These results were corroborated with the data from the video recordings of both the screen and the users playing the game.
- No communication was made with users during the test. They were tested to see how they would behave without intervention.

After the test:

- The users took the interview form which was prepared on Google Forms and the SUS usability test that was taken from SUCourse.
- Results are collected for further evaluation.

c. Task Procedure:

- Users were asked to start from the game's starting screen. First, they were expected to choose level 1 and test the game with VR.
- After level 1, they proceed to level 2 by selecting it.
- The users were expected to complete the levels in the game by using their head movements without hitting any obstacles.
- To complete the levels their aim was to navigate the vehicle towards a tunnel while trying to escape the obstacles and collect the rewards without failing the game.
- Successfully completing the level was not presented as an obligation.

d. Context:

This experiment is part of the Human Computer Interaction CS449 - CS549 course, which focuses on user-based usability testing in virtual reality (VR) environments. The primary goal is to assess the usability and immersion of the VR game "To the Earth's Core VR", identify usability issues and recommend changes. The study includes five individuals with no prior VR experience, balanced by gender and background, who use cardboard VR glasses and a constant mobile phone configuration. To reduce distractions, testing takes place in a quiet atmosphere. Participants play two levels of the game, with their performance and reactions recorded. Post-test interviews and the System Usability Scale (SUS) questionnaire are used to collect qualitative and quantitative data. This experiment aims to provide insights into usability issues and immersion elements, as well as recommendations for improving the VR experience of the game. The study is restricted by its limited sample size and controlled testing circumstances.

e. Tool: iPhone 15 which has 6.1 inch OLED screen with 147,6 mm height and 71,6 mm width. Also it has 2556 x 1179 px resolution 460 ppi pixel density.

2. Results

User 1

Persona: Esma Günay, 23 year old female undergraduate CS student at Sabancı University. She has a medium level of experience at playing game and has no prior VR experience.



Figure 1.1: Esma experiencing the VR game "To the Earth's Core VR"

A. Data Collected During Test

At the start of the game, during the intro, she was confused about whether the game had started. Initially, she didn't understand how to "press" the buttons, but she later figured out that she should be looking at the buttons while the eye symbol is on them. At the beginning of level 1, on her first try, she stated that she was really confused about how to play the game. As she progressed through level 1, she mentioned that it was easier to close one eye and play the game because the screen was blurrier when she played with both eyes open. She also reported difficulty controlling the ship and mentioned that she couldn't see the ship clearly when it was close to the sides of the screen. During her first attempt at level 1, she almost dropped the phone

and subsequently failed the level. Her first attempt took approximately 1 minute and 15 seconds. During this attempt, she collected about 6 oil barrels, 5 repair kits, and 3 bolts, and crashed into her surroundings about 8 times.

She restarted the game and began her second attempt at level 1. Once again, she stated that she had difficulty controlling the ship and collecting repair kits. She reiterated that playing with one eye was better for seeing where the ship was. Shortly after, she failed level 1 again. Her second attempt took approximately 1 minute and 37 seconds. During this attempt, she collected about 14 oil barrels, 4 repair kits, and 1 bolt, and crashed into her surroundings about 6 times.

After failing level 1 twice, she moved on to level 2. She failed almost immediately on her first attempt at level 2, without progressing further in the level. Her first attempt took approximately 11 seconds. She collected 0 oil barrels, 0 repair kits, and 0 bolts, and crashed into her surroundings 0 times.

She restarted the game and began her second attempt at level 2. However, she failed almost immediately again, without progressing further in the level. Her second attempt took approximately 18 seconds. During this attempt, she collected 0 oil barrels, 0 repair kits, and 2 bolts, and crashed into her surroundings 0 times. In the end she couldn't pass both the level 1 and level 2.

B. Post Interview

- Were there any instructions? If yes, how effective and clear were they?**

A: No

- How difficult is coordinating the game with your movements? (1:Very Easy - 5: Very Hard)**

A: 5

- **Were there any moments where you felt confused or lost in the game?**

A: Yes, the beginning part, I didn't understand how to start the game and I didn't see the cursor right away

- **How would you rate the ease of use of the VR headset and the mobile application setup? (1:Very Easy - 5: Very Hard)**

A: 4

- **How hard is it to navigate the game through the game interface (i.e. usage of the buttons)? (1:Very Easy - 5: Very Hard)**

A: 1

- **How easy or difficult was it for you to understand how to play the game? (1:Very Easy - 5: Very Hard)**

A: 2

- **Did the game provide any tutorial or instructions at the start? If so, how helpful were they?**

A: No it didn't.

- **How much did you understand the meaning of the icons and symbols used in the game? (1:Low - 5: High)**

A: 4

- **Were there any icons or symbols that you found confusing or unclear?**

A: No

- **How clear was it to understand how to complete the level and earn points while playing?(end goal) (1:Very confusing - 5: Very clear)**

A: 2

- **How much did you experience any discomfort or fatigue while playing (e.g., eye strain, dizziness)?**

A: 4

- **During the gameplay, was the screen image clear or blurry?**

A: 4

- **How comfortable was the VR headset during gameplay?**

A: 1

- **How realistic did the virtual environment feel to you?**

A: 2

- **Were there any specific elements that enhanced your sense of immersion (e.g., graphics, sound, storyline)?**

A: No.

- **How immersed did you feel while playing the VR game? (How much did you feel engaged?)**

A: 1

- **Were there any elements that broke your immersion or reminded you that you were not actually in the game world?**

A: No.

- **Did you feel any emotional reactions (e.g., excitement, frustration) during the game? Please explain.**

A: Yes, Stres, I couldn't control the vehicle.

- **How strong was your emotion?**

A: 3

- **How challenging did you find to complete the tasks in the game?**

A: 5

- **What were the challenges that you encountered during gameplay?**

A: Vision was bad, I couldn't see the vehicle properly sometimes and it was kinda hard to concentrate while talking. Collecting things was kinda difficult

- **How would you describe your overall experience with the VR game?**

A: A new experience.

- **What did you like most about the VR game?**

A: Fun.

- **What did you like least about the VR game?**

A: Hard to control with a phone.

- **What improvements would you suggest for the VR game to enhance usability?**

A: The image looked double or blurry, and it didn't seem to move exactly according to my eye movements.

- **What could be done to make the game more immersive and captivating?**

A: A little information before about what we are gonna see.

C. Post-test Results

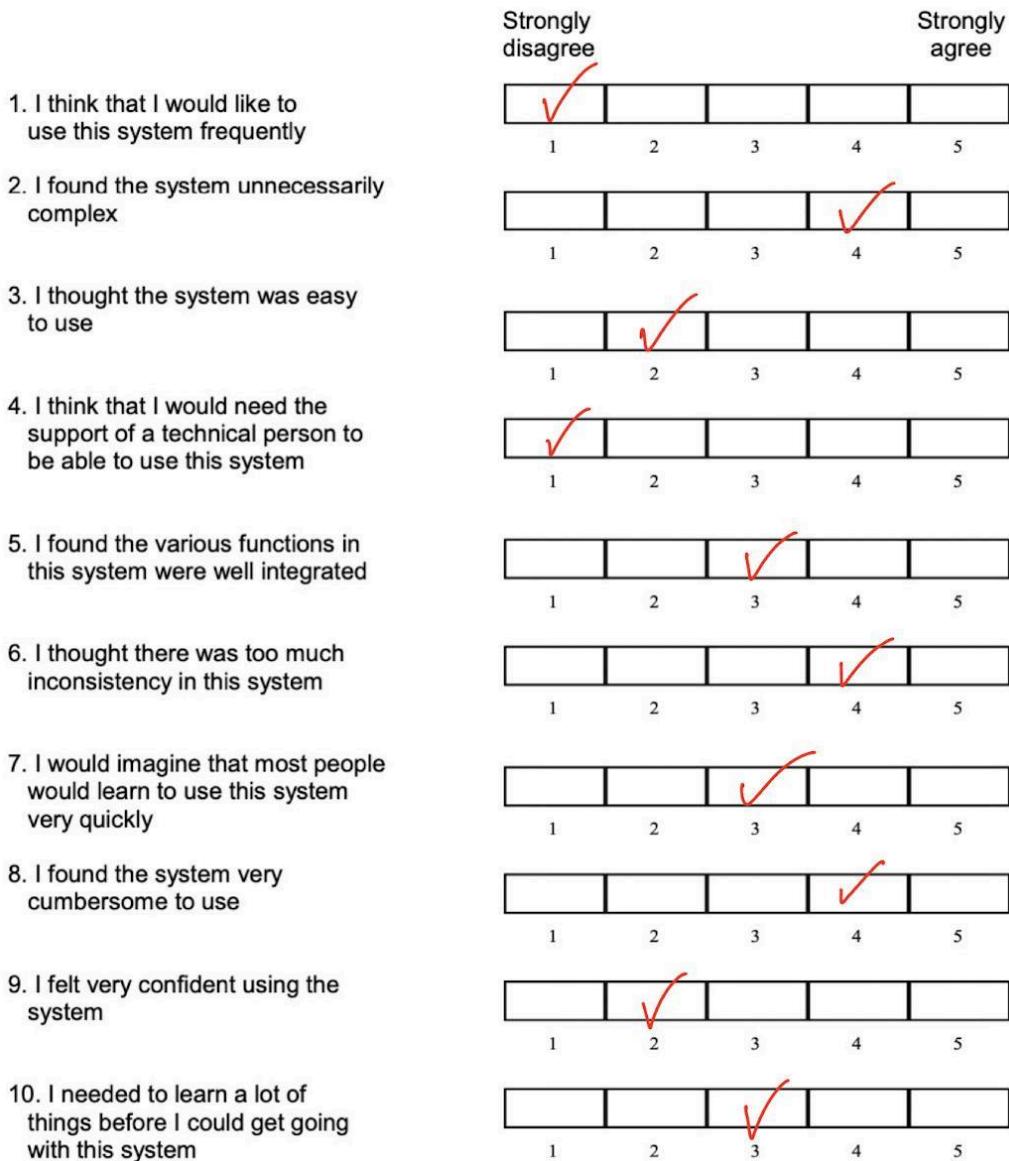


Figure 1.2: Esma's SUS (System Usability Scale) results for VR game "To the Earth's Core VR".

User 2

Persona: Elif Berfu Evliya, 21 years old female undergraduate VA student at Sabanci University. She has a medium level of gaming experience and no prior VR experience.



Figure 2.1: Berfu experiencing VR game "To the Earth's Core VR".

A. Data Collected During Test

After starting Level 1, Berfu confused the shape of the repair kits with the treasure chest and had a confusion. She stated that while she was trying to take the bolts, she could not fully understand whether she had taken them or not. There were poles on the game map that she shouldn't hit, and she mentioned that she didn't quite understand how to avoid them, meaning she had a problem controlling the vehicle. Another problem she mentioned was that she couldn't see her life. She stated that this was due to the bar's logo showing her health being armor.

Afterwards, she stated that the image was blurry and said that she played better when she closed one eye. She also stated that she could not see the text that appeared above while the game was being played. At the same time, since she could not understand what the bolts were for, she thought they were repair kits. In her first attempt, she spent 1 minute and 25 seconds. Also, she collected 9 oil barrels, 7 repair kits, 1 bolt, and she crashed into the surrounding items 7 times.

The second time she played Level 1, she was able to understand that the space ship was moving in the direction of the cursor in the middle of the screen. When she finished the first level, she saw two separate bolt numbers in the reward section and said that win and level were written under them, but she could not understand what they were. On the other hand, she spent 2 minutes and 10 seconds during her second attempt in level 2. She collected 24 oil barrels, 16 repair kits, 13 bolts, and she crashed into the surrounding items 6 times during her successfully ended second attempt.

When level 2 has started, a new item is added to the game: rocket. Since she was not given information about the rocket at the beginning of Level 2, she said that she did not know what she had to collect and started collecting rockets late. At the same time, since the shooting mechanism was not explained, she had to learn it by experience in the game. When she came to the monster in her first attempt at Level 2, she was killed by the monster within a few seconds because she did not know how to kill it. In the first level 2 attempt, she spent 1 minute 47 seconds. Moreover, she collected 16 oil barrels, 17 repair kits, 8 bolts, 12 rockets, and she crashed into the surroundings 10 times. While she was fighting against the monster, she hit the monster 2 times successfully.

In her second attempt at level 2, she stated that she still did not fully understand how the rocket was fired. She couldn't fire rockets at the targets for a while and couldn't understand why, then she said he ran out of rockets and couldn't see it because the number of rockets was on the edge of the screen. When you kill the monster, the words "Yay, we won!" appear on the screen. She thought that she had completed level 2 because of the writing, and then she crashed into something and could not complete level 2. She spent 2 minutes and 51 seconds on her almost successfully ended second attempt. She collected 20 oil barrels, 16 repair kits, 13 bolts, 22

rockets, and she crashed into the surroundings 8 times. During her fight against the monster, she successfully hit the monster 8 times and beat it.

B. Post Interview

- **Were there any instructions? If yes, how effective and clear were they?**

A: Yes, there was, but because the spaceship was moving too fast, it disappeared before he could read the explanations. It wasn't very effective in my understanding of the game.

- **How difficult is coordinating the game with your movements? (1:Very Easy - 5: Very Hard)**

A: 3

- **Were there any moments where you felt confused or lost in the game?**

A: Yes, in the worm section on Level 2, the perspective is so bad that one feels like they are inside the worm's mouth. I also noticed much later that it was firing missiles at the very edges of the screen.

- **How would you rate the ease of use of the VR headset and the mobile application setup? (1:Very Easy - 5: Very Hard)**

A: 3

- **How hard is it to navigate the game through the game interface (i.e. usage of the buttons)? (1:Very Easy - 5: Very Hard)**

A: 3

- **How easy or difficult was it for you to understand how to play the game? (1:Very Easy - 5: Very Hard)**

A: 3

- **Did the game provide any tutorial or instructions at the start? If so, how helpful were they?**

A: Yes, there was, but because the spaceship was moving too fast, it disappeared before he could read the explanations. It wasn't very effective in my understanding of the game.

- **How much did you understand the meaning of the icons and symbols used in the game? (1:Low - 5: High)**

A: 2

- **Were there any icons or symbols that you found confusing or unclear?**

A: I couldn't tell the difference in the icons I collected. For example, what was the purpose of the bolt?

- **How clear was it to understand how to complete the level and earn points while playing?(end goal) (1:Very confusing - 5: Very clear)**

A: 3

- **How much did you experience any discomfort or fatigue while playing (e.g., eye strain, dizziness)?**

A: 4

- **During the gameplay, was the screen image clear or blurry?**

A: 4

- **How comfortable was the VR headset during gameplay?**

A: 3

- **How realistic did the virtual environment feel to you?**

A: 3

- **Were there any specific elements that enhanced your sense of immersion (e.g., graphics, sound, storyline)?**

A: No.

- **How immersed did you feel while playing the VR game? (How much did you feel engaged?)**

A: 2

- **Were there any elements that broke your immersion or reminded you that you were not actually in the game world?**

A: No.

- **Did you feel any emotional reactions (e.g., excitement, frustration) during the game? Please explain.**

A: Yes, I was angry with the game because I couldn't understand the levels when I played them for the first time.

- **How strong was your emotion?**

A: 4

- **How challenging did you find to complete the tasks in the game?**

A: 4

- **What were the challenges that you encountered during gameplay?**

A: It was difficult to kill the monster and pass through the poles.

- **How would you describe your overall experience with the VR game?**

A: It was so dizzying. After taking off my glasses, I realized that I was feeling dizzy.

- **What did you like most about the VR game?**

A: I can play the game with my eyes and movements rather than my hands.

- **What did you like least about the VR game?**

A: Makes me dizzy.

- **What improvements would you suggest for the VR game to enhance usability?**

A: Clearer graphics and clear language could be used.

- **What could be done to make the game more immersive and captivating?**

A: The grandfather in the game can give a tutorial in a section separate from the levels, it would interest me more if I understood the game.

C. Post-test Results

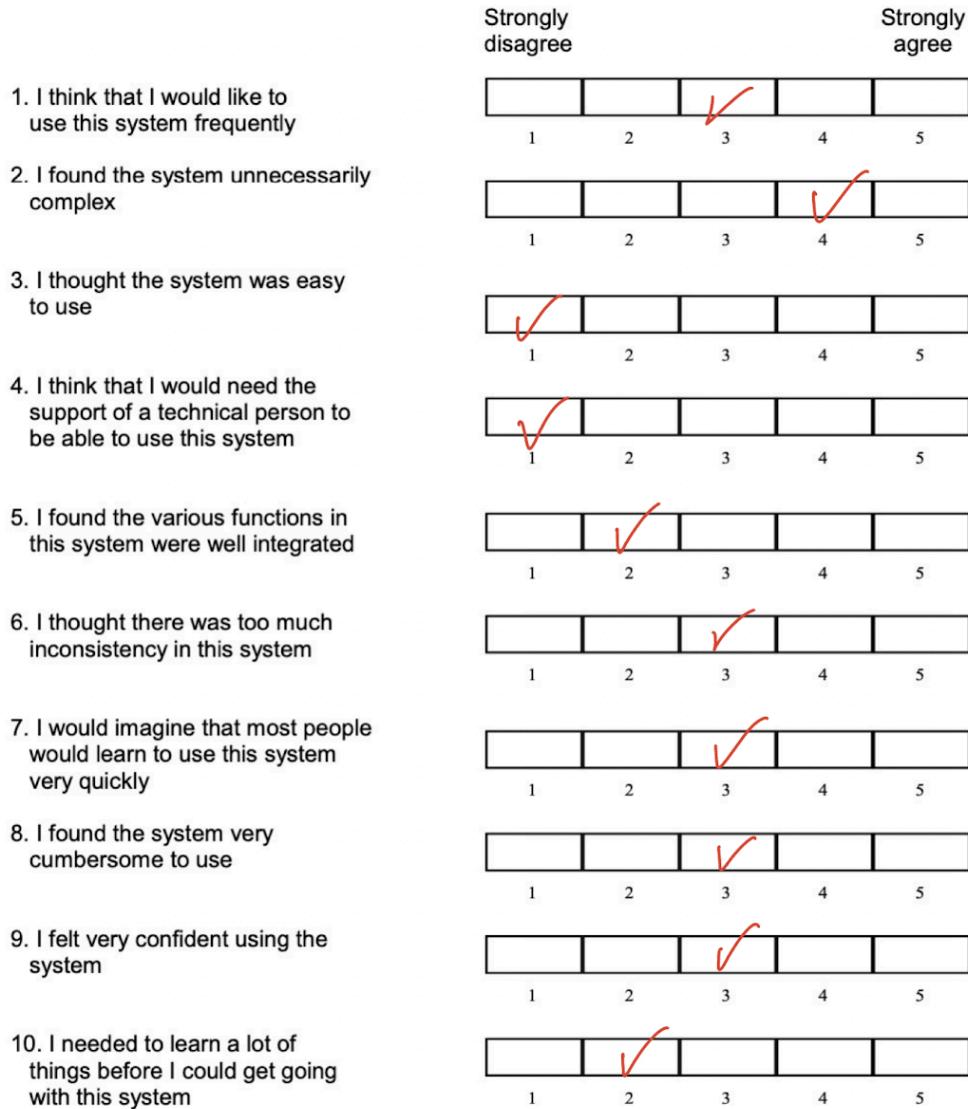


Figure 2.2: Berfu's SUS (System Usability Scale) results for VR game "To the Earth's Core VR".

User 3

Persona: Emirhan Özdemir, 23 year old male undergraduate CS student at Sabancı University. He has a high level of experience at playing game and has no prior VR experience.



Figure 3.1: Emirhan experiencing VR game "To the Earth's Core VR"

A. Data Collected During Test

At his first attempt at level 1, when he started the game, he stated that he couldn't figure out how to move the ship. He mentioned that it was hard to control the ship and that he didn't understand what the treasure box icons represented, which actually stand for repair kits. He felt that too much head movement was required to play the game. Additionally, he mentioned that he didn't understand the meaning and purpose of the oil barrel icons, which are fuels for the ship to keep flying in the game. He also said that he saw the game as blurry and couldn't distinguish between the oil barrels and the treasure boxes. He expressed that he had no idea what he was

doing and subsequently failed level 1 on his first attempt. In this attempt, he spent 1 minute and 40 seconds, collected 13 oil barrels, 5 repair kits, 2 bolts, and crashed into the surrounding items 7 times.

On his second attempt at level 1, he restarted the game. He stated that he saw everything in double, meaning that everything seemed to have shadows on the screen. He managed to pass level 1 by reaching the parking area. In this attempt, he spent 2 minutes and 10 seconds, collected 17 oil barrels, 12 repair kits, 6 bolts, and crashed into the surrounding items 9 times.

After passing level 1, he moved on to level 2, where he failed on his first attempt. In this attempt, he spent 31 seconds, collected 2 oil barrels, 3 repair kits, 0 bolts, and crashed into the surrounding items 3 times.

He restarted level 2 for a second attempt. He stated that it was really hard to control the ship and didn't understand why everything was so close together while the ship's control was this difficult. He failed again and couldn't pass level 2. In this attempt, he spent 28 seconds, collected 1 oil barrel, 2 repair kits, 0 bolts, and crashed into the surrounding items 4 times. In the end, he passed level 1 on his second attempt but failed level 2 in two attempts.

B. Post Interview

- **Were there any instructions? If yes, how effective and clear were they?**

A: Yes, but not clear.

- **How difficult is coordinating the game with your movements? (1:Very Easy - 5: Very Hard)**

A: 4

- **Were there any moments where you felt confused or lost in the game?**

A: Yes, I did not understand the components' functionality.

- **How would you rate the ease of use of the VR headset and the mobile application setup? (1:Very Easy - 5: Very Hard)**

A: 4

- **How hard is it to navigate the game through the game interface (i.e. usage of the buttons)? (1:Very Easy - 5: Very Hard)**

A: 4

- **How easy or difficult was it for you to understand how to play the game? (1:Very Easy - 5: Very Hard)**

A: 3

- **Did the game provide any tutorial or instructions at the start? If so, how helpful were they?**

A: Yes, but not clear.

- **How much did you understand the meaning of the icons and symbols used in the game? (1:Low - 5: High)**

A: 1

- **Were there any icons or symbols that you found confusing or unclear?**

A: Everything is unclear.

- **How clear was it to understand how to complete the level and earn points while playing?(end goal) (1:Very confusing - 5: Very clear)**

A: 2

- **How much did you experience any discomfort or fatigue while playing (e.g., eye strain, dizziness)?**

A:5

- **During the gameplay, was the screen image clear or blurry?**

A: 4

- **How comfortable was the VR headset during gameplay?**

A: 1

- **How realistic did the virtual environment feel to you?**

A: 1

- **Were there any specific elements that enhanced your sense of immersion (e.g., graphics, sound, storyline)?**

A: No.

- **How immersed did you feel while playing the VR game? (How much did you feel engaged?)**

A: 1

- **Were there any elements that broke your immersion or reminded you that you were not actually in the game world?**

A: Yes, I have not felt immersed.

- **Did you feel any emotional reactions (e.g., excitement, frustration) during the game? Please explain.**

A: No.

- **How strong was your emotion?**

A: 1

- **How challenging did you find to complete the tasks in the game?**

A: 4

- **What were the challenges that you encountered during gameplay?**

A: I cannot focus on the game, I saw everything blurry, I did not understand the component's functionality, instructions were not clear and the game was not engaging.

- **How would you describe your overall experience with the VR game?**

A: With respect to this system, painful experience. It hurt my eyes.

- **What did you like most about the VR game?**

A: Nothing.

- **What did you like least about the VR game?**

A: It hurts.

- **What improvements would you suggest for the VR game to enhance usability?**

A: Easy to use game design.

- **What could be done to make the game more immersive and captivating?**

A: More clear instructions, high resolution images.

C. Post-test Results

1. I think that I would like to use this system frequently
 2. I found the system unnecessarily complex
 3. I thought the system was easy to use
 4. I think that I would need the support of a technical person to be able to use this system
 5. I found the various functions in this system were well integrated
 6. I thought there was too much inconsistency in this system
 7. I would imagine that most people would learn to use this system very quickly
 8. I found the system very cumbersome to use
 9. I felt very confident using the system
 10. I needed to learn a lot of things before I could get going with this system

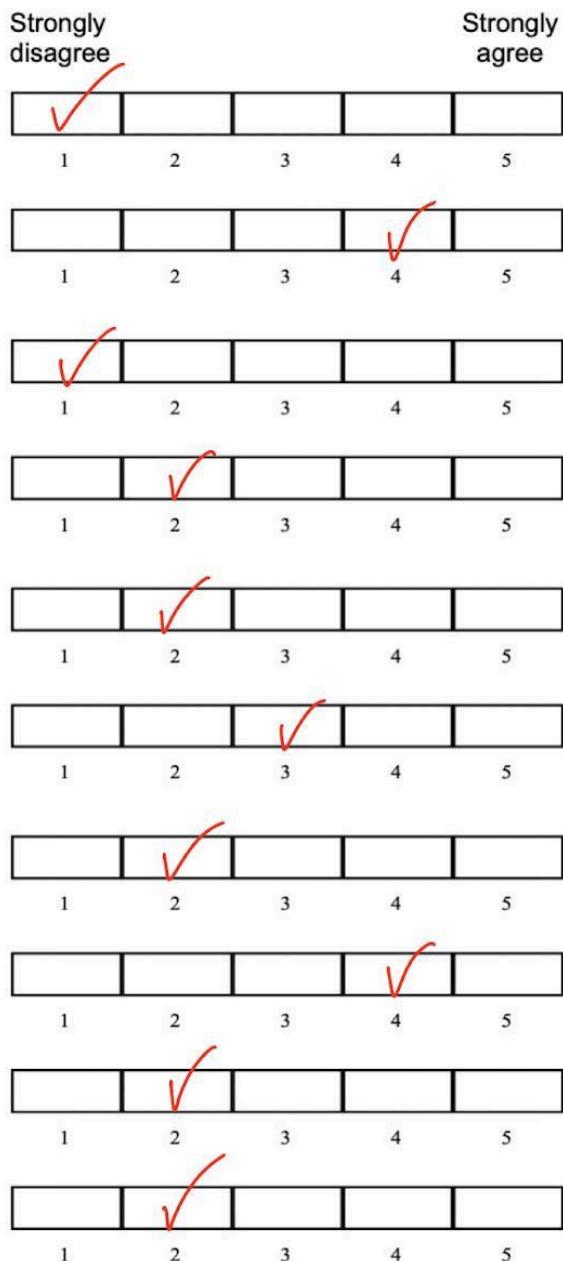


Figure 3.2: Emirhan's SUS (System Usability Scale) results for VR game "To the Earth's Core VR".

User 4

Persona: Pelinsu Sarac, 21 years old female undergraduate CS student at Sabancı University.

She has a low level of gaming experience and no prior VR experience.



Figure 4.1: Pelinsu experiencing VR game "To the Earth's Core VR".

A. Data Collected During Test

Before she started playing the game she needed to take some time to find the start button. She described that this process requires too much spinning around and it was unnecessary. Shortly after she started playing, she said consequent rewards in the game are too close and it is very hard to collect the new award after collecting one. She also mentioned that the ship moves very slowly turning in different directions which makes it very hard to navigate. After the middle of the level 1, she noticed that the game was starting to be blurry and seeing obstacles became hard. Like the consequent rewards, rewards after previous obstacles were too close with each other for her to collect. Despite these complaints about the game her performance was very high in level 1. She accomplished the level in her first attempt in 1 minute and 10 seconds. She collected 24 oil barrels, 17 repair kits, 7+10 bolts (10 bolts were bonus), and 8 rockets. She crashed only four times.

While she was starting level 2, she mentioned that buttons like “continue” or level selection buttons were either too high or too low and hard to reach by head movements. She had a bad feeling when she started the second level because of looking down and the effect of falling. She mentioned that the cursor moves very slowly for collecting the loot or escaping obstacles again. Also, the cursor’s color is too close to the background color and it was very hard to see, she said. Pelinsu had a hard time finding her way because the game sometimes felt like it was 2D. Stats are not visible enough to notice at the first glance according to her. Warnings were not readable as she described and it was very hard for her to understand what the game expects from users.

She attempted the second level 2 times but she couldn’t complete it even though she was successful at the first one. The first attempt took 1 minute and 49 seconds. She collected 11 oil barrels, 17 repair kits, 12 bolts, and 10 rockets. She crashed 6 times and was shot by the monster 2 times before she failed. In the second attempt for second level she endured 2 minutes and 23 seconds. She collected 15 oil barrels, 17 repair kits, 4 bolts, and 8 rockets. She crashed 9 times and was shot by the monster before she failed the level. She couldn’t kill the monster.

B. Post Interview

- **Were there any instructions? If yes, how effective and clear were they?**

A: There were some but it was hard for me to read while controlling the game

- **How difficult is coordinating the game with your movements? (1:Very Easy - 5: Very Hard)**

A: 5

- **Were there any moments where you felt confused or lost in the game?**

A: At level 2, when the monster comes, I only understood what I have to do after I stopped playing the game. Plus, even if I aim for some of the prizes, I couldn’t get them.

- **How would you rate the ease of use of the VR headset and the mobile application setup? (1:Very Easy - 5: Very Hard)**

A: 5

- **How hard is it to navigate the game through the game interface (i.e. usage of the buttons)? (1:Very Easy - 5: Very Hard)**

A: 2

- **How easy or difficult was it for you to understand how to play the game? (1:Very Easy - 5: Very Hard)**

A: 3

- **Did the game provide any tutorial or instructions at the start? If so, how helpful were they?**

A: For me, no there was not

- **How much did you understand the meaning of the icons and symbols used in the game? (1:Low - 5: High)**

A: 4

- **Were there any icons or symbols that you found confusing or unclear?**

A: There were some nuts to collect, I assumed they were the coins, but then there was a treasure chest

- **How clear was it to understand how to complete the level and earn points while playing?(end goal) (1:Very confusing - 5: Very clear)**

A: 3

- **How much did you experience any discomfort or fatigue while playing (e.g., eye strain, dizziness)?**

A: 4

- **During the gameplay, was the screen image clear or blurry?**

A: 4

- **How comfortable was the VR headset during gameplay?**

A: 1

- **How realistic did the virtual environment feel to you?**

A: 1

- **Were there any specific elements that enhanced your sense of immersion (e.g., graphics, sound, storyline)?**

A: No.

- **How immersed did you feel while playing the VR game? (How much did you feel engaged?)**

A: 2

- **Were there any elements that broke your immersion or reminded you that you were not actually in the game world?**

A: Even if I aimed I could not get the prizes, I lost the sense of realism.

- **Did you feel any emotional reactions (e.g., excitement, frustration) during the game? Please explain.**

A: Frustration and tension as I did not know whether I would make it to the end.

- **How strong was your emotion?**

A: 3

- **How challenging did you find to complete the tasks in the game?**

A: 3

- **What were the challenges that you encountered during gameplay?**

A: Even if I aimed the prizes I could not get them and it was hard to see whether I have enough fuel or something

- **How would you describe your overall experience with the VR game?**

A: Not so nice, eye tiring (consider I have migraine onset)

- **What did you like most about the VR game?**

A: I cannot say that I enjoyed it.

- **What did you like least about the VR game?**

A: Moving my head to move the ship is not intuitive at all. Humans engage with tools with their hands most of the time.

- **What improvements would you suggest for the VR game to enhance usability?**

A: Integrate some game controllers immediately.

- **What could be done to make the game more immersive and captivating?**

A: The ship should not “drop” it should “take off” and “fly”.

C. Post-test Results

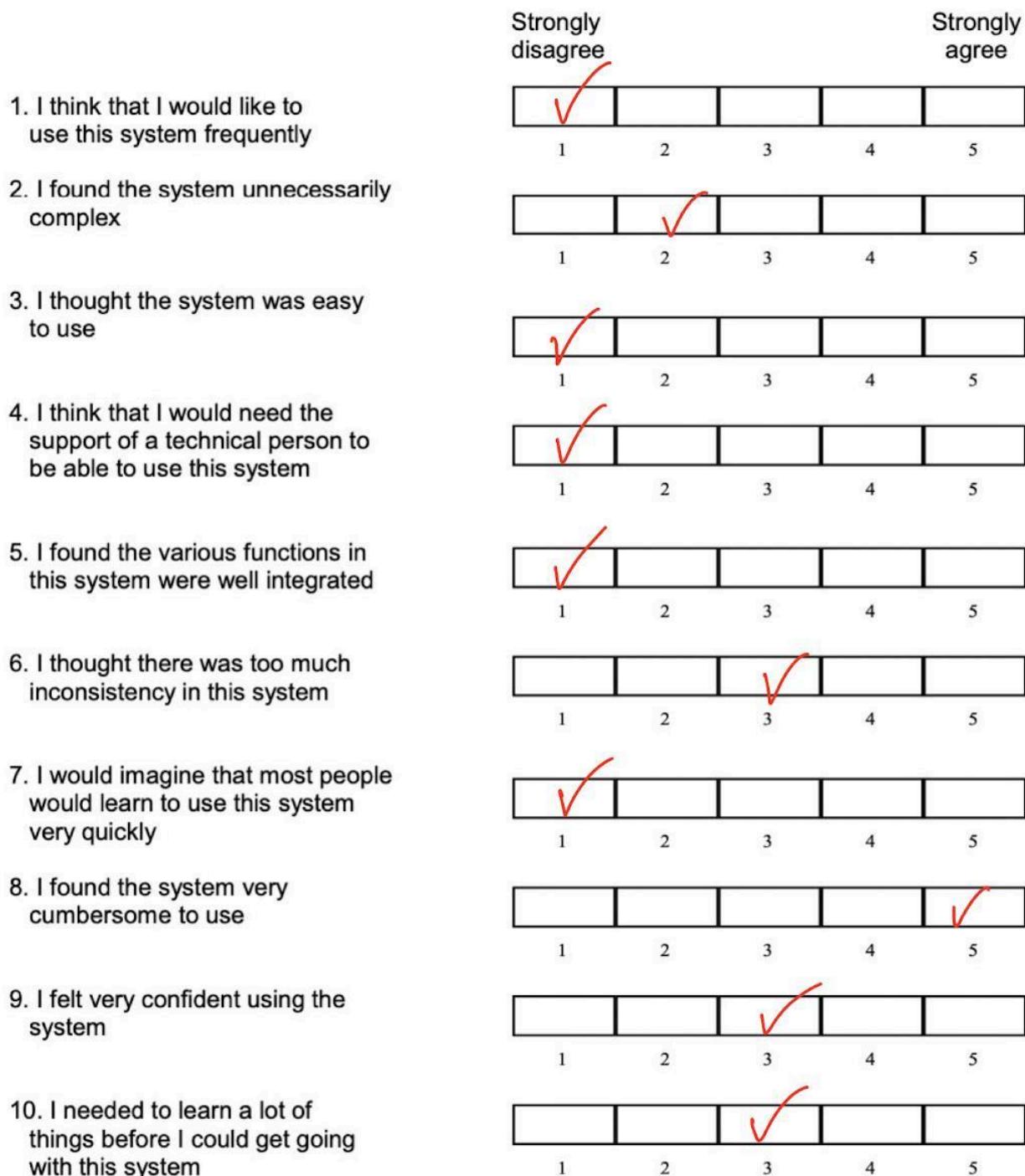


Figure 4.2: Pelinsu's SUS (System Usability Scale) results for VR game "To the Earth's Core VR".

User 5

Persona: Barış Çukur, 22 year old male undergraduate CS student at Sabancı University. He has a high level of experience at playing games and has no prior VR experience.



Figure 5.1: Barış experiencing VR game "To the Earth's Core VR"

A. Data Collected During Test

Shortly after starting the Level 1 of the game, Barış mentioned that the resolution quality of the game was not good. A few seconds after starting Level 1, he stated that he could not understand whether the game was third person or FPS. In the first attempt of Level 1, he continued by assuming that he saw the ship on the screen as an FPS from another ship following it. He couldn't fully grasp how the controls worked, how much and in which way he should move his head, on his first try. He mentioned that it might be better to be an FPS rather than playing as Third Person because it is difficult to understand how and at what speed he should move his head while controlling the ship while playing in third person. He mentioned that he was experiencing dizziness because he moved his head a lot to get the power-ups in the game. He also said that when he wanted to look at the images in the UI, his ship experienced crashes because it was going in that direction at the same time. As a result, he could not complete Level 1 successfully.

In his first attempt at Level 1, he spent 1 minute and 18 seconds and failed at Level 1. During this time, he collected 6 oil barrels, 4 repair kits and 2 bolts. He crashed into the surrounding obstacles 6 times. His second attempt at Level 1 lasted 1 minute and 47 seconds and he failed to complete Level 1. During this time, he collected 13 oil barrels, 11 repair kits and 5 bolts. He crashed into the surrounding obstacles 11 times.

While playing Level 2, he mentioned that it was better to play with one eye closed instead of playing with both eyes open. He also had an issue with his head not adjusting to his position at the start of the game. He stated that he needed to play faster and with sudden movements in Level 2, so he was not successful in completing the game.

His first attempt at Level 2 took 31 seconds and he failed to complete Level 2. During this time, he could not collect any oil barrels and repair kits, but he collected 5 bolts. He crashed into the surrounding obstacles 3 times. He didn't use any rockets or there were no rockets around and the level ended before he could even reach the monster. In his second attempt at Level 2, he spent 1 minute and 2 seconds and could not complete the level. He bought 1 oil barrel, 5 repair kits and 8 bolts. He used rockets 5 times and took 3 rockets from the surrounding area. He hit the surrounding obstacles 8 times and therefore the level ended unsuccessfully before reaching the monster.

B. Post Interview

- **Were there any instructions? If yes, how effective and clear were they?**

A: Yes, they were effective and talked me through the steps.

- **How difficult is coordinating the game with your movements? (1:Very Easy - 5: Very Hard)**

A: 5

- **Were there any moments where you felt confused or lost in the game?**

A: Yes, I first thought I was not controlling the ship

- **How would you rate the ease of use of the VR headset and the mobile application setup? (1:Very Easy - 5: Very Hard)**

A: 4

- **How hard is it to navigate the game through the game interface (i.e. usage of the buttons)? (1:Very Easy - 5: Very Hard)**

A: 2

- **How easy or difficult was it for you to understand how to play the game? (1:Very Easy - 5: Very Hard)**

A: 4

- **Did the game provide any tutorial or instructions at the start? If so, how helpful were they?**

A: The game only had level selections and brief instructions. They were not terribly helpful

- **How much did you understand the meaning of the icons and symbols used in the game? (1:Low - 5: High)**

A: 2

- **Were there any icons or symbols that you found confusing or unclear?**

A: Yes

- **How clear was it to understand how to complete the level and earn points while playing?(end goal) (1:Very confusing - 5: Very clear)**

A: 3

- **How much did you experience any discomfort or fatigue while playing (e.g., eye strain, dizziness)? (1: Not much - 5: Very much)**

A: 4

- **During the gameplay, was the screen image clear or blurry? (1: Very clear - 5: Very blurry)**

A: 5

- **How comfortable was the VR headset during gameplay? (1: Not comfortable - 5: Very comfortable)**

A: 1

- **How realistic did the virtual environment feel to you? (1: Not realistic at all - 5: Very realistic)**

A: 1

- **Were there any specific elements that enhanced your sense of immersion (e.g., graphics, sound, storyline)?**

A: No

- **How immersed did you feel while playing the VR game? (How much did you feel engaged?) (1: Not much - 5: Very much)**

A: 2

- **Were there any elements that broke your immersion or reminded you that you were not actually in the game world?**

A: Yes, The light bleeding out of the VR headset. Also its discomfort

- **Did you feel any emotional reactions (e.g., excitement, frustration) during the game? Please explain.**

A: Yes, I felt confused about the gameplay

- **How strong was your emotion? (1: Very weak - 5: Very strong)**

A: 4

- **How challenging did you find to complete the tasks in the game? (1: Not much - 5: Very much)**

A: 2

- **What were the challenges that you encountered during gameplay?**

A: Keeping the ship alive

- **How would you describe your overall experience with the VR game?**

A: It was not immersive and was confusing

- **What did you like most about the VR game?**

A: I liked the smooth gameplay

- **What did you like least about the VR game?**

A: The lack of immersion

- **What improvements would you suggest for the VR game to enhance usability?**

A: A higher resolution display and a more comfortable HMD

- **What could be done to make the game more immersive and captivating?**

A: I'd add easier controls and a tutorial prologue to make the game easier to grasp for beginners

C. Post-test Results

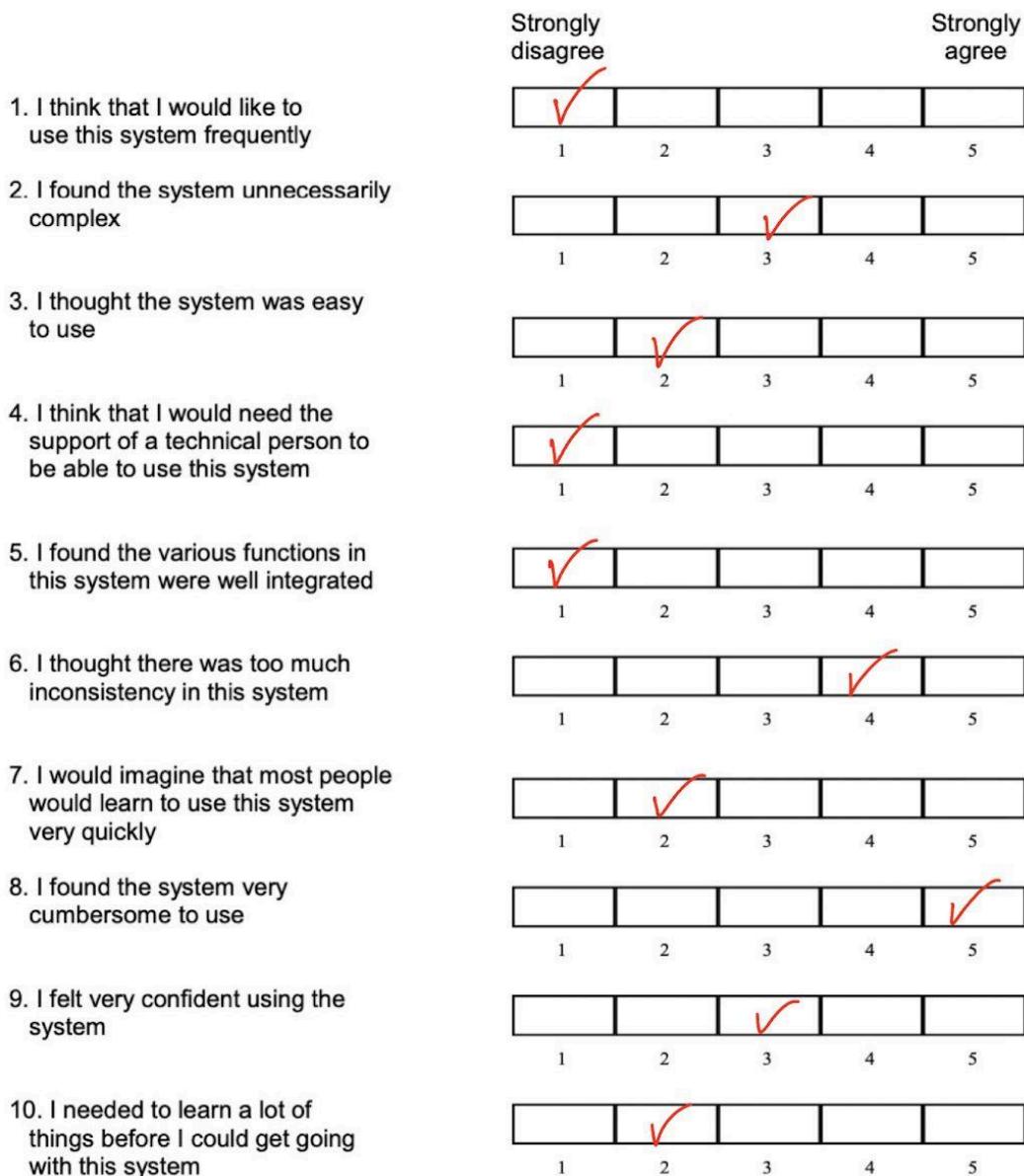


Figure 1.6: Barış's SUS (System Usability Scale) results for VR game "To the Earth's Core VR".

Evaluation of Post-test Results

The Question	Esma	Barış	Berfu	Pelinsu	Emirhan	Average
Wanting to use the system again	1	1	3	1	1	1,4
Complexity	4	3	4	2	4	3,4
Easy to use	2	2	1	1	1	1,4
Need for technical support	1	1	1	1	2	1,2
Integration of functions	3	1	2	1	2	1,8
Inconsistency	4	4	3	3	3	3,4
Learning rate	3	2	3	1	2	2,2
Cumbersomeness	4	5	3	5	4	4,2
Confidence for using it again	2	3	3	3	2	2,6
Cognitive load	3	2	2	3	2	2,4

Table 2: SUS results for VR game "To the Earth's Core VR" of all users.

3. Conclusion

What data tells us about the application and what are the usability issues?

Significant difficulties and flaws in the game's conception and production are depicted in the data acquired from player encounters with the VR gaming application. Players frequently brought up the annoyance and confusion they experienced from not being able to control their in-game ships and coordinate their maneuvers. In addition, a lot of gamers mentioned that they had trouble seeing, including double vision and blurriness, which made it difficult for them to interact with the gaming world to the fullest. Furthermore, the absence of comprehensive guidelines and tutorials made it more difficult for players to comprehend gameplay dynamics, which made it difficult for them to complete stages and accomplish goals. Players frequently felt disengaged and irritated despite their best efforts to become fully immersed in the game, underscoring the necessity for significant advancements in usability and user experience.

Resolving these concerns is essential to improving player contentment and encouraging increased interaction with the virtual reality gaming program.

How can we improve the application?

Enhanced Onboarding: Start the game with a thorough tutorial that covers all of the controls, goals, and ways to interact with the game. It helps reduce the confusion of the users.

Control Optimization: Enhance the ship's controls' responsiveness and clarity. Take into account substitute control strategies that reduce the requirement for excessive head motions. As one of the users mentioned, control can be FPS rather than the first person. In this way the feeling of dizziness can be decreased.

Visual Enhancements: Make sure the game can be played comfortably with both eyes open by addressing concerns with visual clarity. Reduce blurriness by improving the overall quality of the image, also users may not get headaches easily due to this issue.

Clear Feedback Mechanisms: Improve in-game feedback by making health, gathered items, and objective indications more visible and comprehensible. Warnings and instructions should be more visible.

Inform Users About New Features: Introduce new game elements, providing practice chances and clear instructions to assist users adjust to the changes without difficulty.

What are the limitations of the study?

The limited sample size of the study restricts how far the results may be applied. In our context, it was specified that individuals should not have had any prior VR experience, but generally speaking, participants can be chosen based on their prior VR experience, which may better represent the diversity of potential users and yield better results. There might have been equipment-specific biases introduced by using a single cell phone and cardboard VR glasses. As such, it could result in a physical restriction.

How can the test be improved (Future study suggestions)?

1. Greater in Number and Variety Group of Participants:

Expand sample size: In order to guarantee a more statistically meaningful dataset, expand the sample size by adding additional individuals. This facilitates the identification of trends and patterns that are characteristic of a larger user base.

Diversity in Demographics: Seek for volunteers with a range of experiences in gaming, ages, genders, and ethnicities, among other factors. This diversity will highlight usability concerns that may impact particular groups and offer insights into how various user types engage with the VR game.

2. Different Testing Environments:

Real-World Settings: Test the game's usability in a range of real-world settings where people are probably to play it. This includes calm residential environments, noisy public areas, and various lighting setups. Testing in a variety of settings will show how outside variables affect usability and user experience.

Modeled Situations: Make regulated settings that mimic various use scenarios—for example, allowing players to play the game while moving, sitting, or standing. This can assist in identifying potential contextual and physical difficulties for users.

3. Experiments with Various VR Headsets and Devices:

Several VR headsets: Try the app with a variety of VR headsets, from advanced ones to less advanced ones, such as cardboard VR glasses. This guarantees that the results of the usability test are not influenced by the benefits or drawbacks of a particular headset.

Test the game on a variety of smartphones and other devices to ensure compatibility. This will make it easier to find any incompatibilities or differences in performance across various hardware setups.

4. Longitudinal Study:

- *Extended Usage Period*: Do long-term research in which participants utilize the virtual reality game for a number of weeks or months. This method can highlight long-term usability and immersion problems that may not show up in short-term testing.
- *Sustained Usability and Engagement*: Monitor changes in the way users interact with the game over time, such as adjustments to their comfort zones, degree of control, and level of involvement. This can offer insightful information about the game's capacity to hold players' attention and deliver a consistently enjoyable experience.

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