User-Based Usability Testing of Virtual Reality Environments

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1. Introduction

This project involves conducting usability testing for a virtual reality (VR) gaming application. Usability testing is crucial in VR environments to ensure a smooth and immersive user experience. Our objective is to evaluate the usability of the VR game "To the Earth's Core VR" by gathering feedback from real users, identifying usability issues, and suggesting improvements.

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2. Methodology

User Personas

1. **Person 1**
   - Age: 18
   - Gender: Male
   - Background: Avid mobile and video game player. Uses glasses.
   - VR Experience: Had very little (max. 10 hours) VR experience, none in the past 4 years.

2. **Person 2**
   - Age: 19
   - Gender: Male
   - Background: Played many mobile and video games during middle and high school. Uses glasses.
   - VR Experience: None
   - Uses technology primarily to stay updated with news.

3. **Person 3**
   - Age: 23
   - Gender: Female
   - Background: Avid mobile game player. Uses glasses.
   - VR Experience: None
   - Uses technology mostly for communication.

4. **Person 4**
   - Age: 23
   - Gender: Female
   - Background: Occasional mobile gamer.
   - VR Experience: Only tried once and had a very limited experience.
   - Uses technology mostly for her school and business work.

5. **Person 5**
   - Age: 23
   - Gender: Female
   - Background: Expert in match-3 and merge games for the past year.
   - VR Experience: None
   - Uses technology primarily for entertainment.

Test Procedure

Before the Test:

● The app "To The Earth's Core VR" was downloaded from Google Play Store and a suitable test environment was found. The screen size of the app was set as "Narrow" due to the specifications of the mobile phone that was used. The cardboard VR that our project group used hurt the upper nose area, so a tissue paper was advised for the users to put on their nose before putting on the VR device.
● A pilot test was conducted before any user usability testing was conducted. In the pilot test it was observed that the game worked as intended, but the screen was not able to be interacted with at eye-level, the users had to look a bit under the interactable buttons for the game to register.

During the Test:

● The test was conducted for each test user separately. Right before starting the test, the users were asked about their experience with VR technologies. Afterwards, the VR glasses, along with the app "To The Earth's Core VR" were handed to the users, and the users were asked to complete the first two levels of the game starting from the main menu. Users were tasked with starting a New Game, and then finishing the first two levels however they saw fit. While conducting the tests, the users were asked to react to the game and think out loud to understand their interpretations. No other instructions or tutorials related to the app or the test were given. The users' head and body movements, thought processes, and comments during testing were collected and noted. The testing time was limited to 15 minutes. The testing was concluded earlier for individuals who managed to complete the first two levels of the game. For users who could not complete the first two levels, after 15 minutes, the test was concluded nevertheless.

After the Test:

● After testing was concluded for each user, the individuals were asked to fill out the System Usability Scale (SUS) for the app "To The Earth's Core VR". While users were filling out the questionnaire, no discussions about the test or comments were made. After the users filled out the survey, general questions regarding their enjoyment and overall satisfaction with the game were asked. Both their survey answers and their comments in the discussion section were collected to get a better understanding of their experience.

Task Procedure

1. Before starting the tests, the users will be asked for their consent on whether they accept their previously stated personal information to be written in the report.
2. The users will be asked to experience the VR game without any instructions about the game given before.
3. The users will be asked to play the first two levels of the game.
4. Throughout the experience, the users will be asked to think aloud to help us observe their reactions.
5. Then, the users will be asked to complete the System Usability Survey (SUS).

6. Lastly, an interview will be conducted to obtain feedback about the factors contributing to usability, immersion, and any usability issues identified.
   - How was your overall experience?
   - Would you play the game again, why?
   - Do you think there were major issues? If yes, what?
   - How could this app be improved?
   - What is your opinion on the usability of the game?
   - Were the instructions clear enough for the user to understand the goal?

Context

- The test was conducted in the class G042 in Sabancı University Faculty of Management. The testing environment was illuminated with the ceiling lights and the users were asked to sit on a swivel chair in the middle of a $10m^2$ empty area for easy maneuverability. The users were informed that the physical movements throughout the experience are up to their preference. The VR glasses were modified with a napkin to prevent any nose damages.

Tool

- **Phone Specifications:**
  - **Model**: Samsung Galaxy S21FE
  - **Screen**: 6.4-inch AMOLED display
  - **Operating System**: Android
  - **Any adjustments made**: None.

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3. Results

During Test Data

During the testing phase, various qualitative observations were recorded. Person #1 had initial difficulties understanding the missile mechanics and believed he needed to walk first. It wasn't until the end of the first level that he realized how to control the vehicle using the reticle. He also misunderstood the significance of the color differences in the collectibles, thinking some should be avoided. Person #2 expressed a strong dislike for the game's music and mistook collectibles for mines. He struggled with understanding how to use the collected items and initially thought he needed to use his whole body for movement. It took him some time to figure out how to proceed to the second level, and he found the rocket mechanics confusing. Additionally, he had difficulty recognizing indicators on the screen.

Person #3 took a considerable amount of time to locate the start button and was unsure which collectibles to gather. She lost during the first level and found it challenging to confirm the "New

Game" option due to sensitivity issues. Despite these challenges, she appreciated the first cutscene and the game's visuals, and eventually understood the health-boosting collectibles. Person #4 also struggled with finding the "New Game" button and was disoriented when the game returned to the main screen after the cutscene. She had difficulty distinguishing good collectibles and encountered an ad during gameplay, which she found highly disruptive. She also felt that the vehicle did not fly correctly. Lastly, Person #5 initially thought she needed to select options with her hand and struggled to understand the button mechanics. She claimed the lower part of the screen was not visible and took time to grasp the game controls. She also had trouble navigating back to the game from the upgrades screen.

Post-Test Interview Results

During the post-test interviews, each user shared their overall experience and feedback on the game. Person #1 found the experience engaging, noting that the game started easy but became challenging by the second level. He expressed a desire to play again to overcome the second level, highlighting a competitive drive. He criticized the lack of tutorials and the awkward head positioning required for gameplay. Despite these issues, he found the game enjoyable and believed it could be even more fun with further development. He felt that the absence of instructions made the game difficult to navigate initially.

Person #2 described the game as exciting but tiring for the eyes, noting that the close proximity of the screen caused eye strain. Although he found the game interesting, it did not captivate him enough to prioritize playing it again. He expressed a preference for story-based games and felt the game lacked clarity in terms of head movements and overall mechanics. He suggested adding subtitles for cutscenes and improving the integration of 2D and 3D elements. While he found the game easy to use, he recommended clearer HUD elements and better instructions.

Person #3 enjoyed the game overall, though she struggled to understand which collectibles to gather at first. She expressed a desire to play again, finding the visuals appealing and the game enjoyable despite the initial difficulties. She believed the game's issues stemmed from her inexperience with VR rather than the game itself. Person #3 suggested adding a tutorial and more interactive elements to enhance the gaming experience. Once she understood the mechanics, she found the game usable but noted the absence of clear instructions.

Person #4 found the game entertaining and enjoyable, rating it as the most fun VR game she had tried. She expressed a willingness to play again, despite some visibility issues with the vehicle. She praised the game for its ease of use but mentioned that the excessive head movements required were a drawback. Person #4 strongly felt that a tutorial would have significantly improved her initial gameplay experience.

Person #5 found the game challenging and slightly dizzying, noting that her pre-existing dizziness concerns affected her gameplay. She found the second level particularly disorienting due to plane changes. Despite this, she expressed a desire to play again, finding the game

enjoyable overall. She suggested improvements in the visibility of HUD elements and a system that involved more body parts, such as fingers, for control. She found the frequent appearance of power-ups confusing and suggested that the game could benefit from better instructions and an introductory tutorial to ease new players into the VR experience.

Post-Test Questionnaire Results

SUS Scores

Reviewer	SUS Score
Person #1	**70**
Person #2	**75**
Person #3	**65**
Person #4	**77.5**
Person #5	**67.5**

Summary of SUS Results

The System Usability Scale (SUS) scores for the users varied, with a range between 65 and 77.5. The average SUS score across all users was 71, which is only slightly above the industry average of 68. The individual scores are as follows: Person #1 scored 70, Person #2 scored 75, Person #3 scored 65, Person #4 scored 77.5, and Person #5 scored 67.5. For SUS metric score specifications of all test users, please refer to Appendices.

Narrative Explanation

The SUS scores provide a quantitative measure of the users' perceived usability of the VR game "To the Earth's Core VR". The overall average score of 71 indicates that the game's usability is, while acceptable, nearly within the marginal acceptability standards and interval.

Interpretation of SUS Scores and Overall User Feedback:

- **Person #1 (70)**: Person #1's score suggests an average satisfaction level with the game's usability. Despite his initial confusion with the game mechanics and head positioning, he found the game enjoyable and was motivated to play again, driven by a competitive spirit. His metric score can be found in Appendix 1.

- **Person #2 (75)**: Person #2's score, while reflecting his difficulties with understanding the game mechanics and his general dissatisfaction with the user experience, represents that he found the system satisfactory. He found the lack of clarity in instructions and head movement requirements to be significant barriers to enjoyment. His metric score can be found in Appendix 2.
- **Person #3 (65)**: Person #3's score, lowest of the users, indicates that while she found the game visually appealing and enjoyable, her initial struggles with game mechanics and lack of clear instructions negatively impacted her overall experience. Her metric score can be found in Appendix 3.
- **Person #4 (77.5)**: Person #4 scored the highest among the users, indicating a relatively positive experience. She appreciated the game's entertainment value despite some technical issues and disruptive advertising. Her willingness to play again highlights the game's potential if the usability issues are addressed. Her metric score can be found in Appendix 4.
- **Person #5 (67.5)**: Person #5's score suggests a slightly-below average level of usability. Her feedback highlighted challenges with dizziness, HUD visibility, and game mechanics understanding, which are crucial areas for improvement. Despite these issues, she found the game enjoyable and expressed interest in replaying it. Her metric score can be found in Appendix 5.

Overall Analysis: The feedback from users indicates that the main areas requiring improvement are the clarity of instructions, HUD visibility, and the mechanics of head movement. The introduction of a tutorial could significantly enhance the initial user experience, helping new players quickly understand how to navigate and interact with the game. Addressing the physical comfort issues, such as screen proximity and head movement requirements, would also likely improve the overall usability score. Despite the usability challenges, the positive aspects, such as the game's visuals and core concept, received favorable feedback, suggesting that with targeted enhancements, the game has the potential to provide a highly engaging and immersive VR experience.

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4. Discussion and Conclusion

Usability Issues

- Lack of tutorials made it hard for users to understand game mechanics.
- Head positioning and movement were uncomfortable and unclear.
- Visual elements such as HUD were not always visible or clear.

During the usability testing of "To the Earth's Core VR," several key issues were identified that impacted the overall user experience. A significant problem noted by all users was the absence

of tutorials or guidance, which made understanding the game mechanics challenging. For instance, Person #1 struggled to grasp the missile mechanics and initially misunderstood the gameplay, thinking he needed to walk. Person #2 found it difficult to figure out how to use collected items and progress to the next level, highlighting the need for clearer instructions and in-game guidance.

Another major usability issue was the discomfort caused by head positioning and movement. Users were required to keep their heads in a downward position to view the screen properly, which was physically uncomfortable over extended periods. This discomfort was mentioned by several users, including Person #1 and Person #2, who found it difficult to maintain the necessary head movements to control the game effectively.

Visual elements such as the Heads-Up Display (HUD) also posed challenges. Some users, like Person #5, reported that they could not see the lower part of the screen, which hindered their ability to fully engage with the game. Person #3 experienced difficulties confirming selections due to sensitivity issues, and Person #4 encountered problems with the visibility of collectibles, leading to confusion about which items to gather. These visual challenges indicate a need for improved HUD design and screen element visibility.

Immersion Experience

- Users found the game visually appealing but were often confused by mechanics.
- Some users experienced physical discomfort due to close screen proximity and head movement.

The level of immersion experienced by users varied, with several factors contributing positively and negatively. On the positive side, users found the game's visuals appealing, which played a crucial role in creating an immersive environment. Person #3 and Person #4, in particular, appreciated the graphics and the engaging visual experience.

However, the immersion was often disrupted by confusion regarding game mechanics and physical discomfort. The lack of tutorials made it difficult for users to understand their objectives and how to interact with the game environment, breaking the sense of immersion. Person #2's experience of mistaking collectibles for mines and his general uncertainty about how to use in-game items exemplifies this issue.

Physical discomfort also detracted from the immersive experience. The close proximity of the screen caused eye strain and dizziness for some users, such as Person #2 and Person #5. The necessity of extensive head movements added to this discomfort, making it difficult for users to stay engaged for extended periods.

User Comfort

- Eye strain and dizziness were common issues.
- Some users felt discomfort due to the necessity of head movements.

User comfort was a significant concern throughout the testing. Several users reported experiencing eye strain and dizziness due to the close proximity of the VR headset's screen. Person #2 noted that his eyes began to water after some time, indicating the need for adjustments in screen distance and display settings to reduce strain.

The requirement for head movements to control the game was another source of discomfort. Person #1 mentioned that he had to keep his head down to play, which was not only physically tiring but also less enjoyable. Person #4 found herself using excessive head movements, which could be streamlined to enhance comfort. These physical discomforts suggest a need for ergonomic improvements in the VR setup and more intuitive control mechanisms.

Study Limitations

- Small sample size and limited diversity.
- Potential biases due to the testing environment and single mobile device usage.

The study had several limitations that should be considered. The sample size was relatively small, with only five participants, which limits the generalizability of the findings. Additionally, the participants lacked diversity in terms of their backgrounds and experiences, which may introduce biases into the results. The testing environment, while controlled to some extent, may not have perfectly simulated real-world conditions, and using a single mobile device for all tests could have influenced the outcomes.

Future Study Suggestions

- Increase sample size and diversity.
- Include more comprehensive tutorials and clearer instructions.
- Explore different VR setups to reduce physical discomfort.
- Incorporate user feedback into game design improvements.

To improve future studies, several recommendations can be made. Increasing the sample size and ensuring a more diverse participant pool would provide a broader perspective on the usability and immersion issues. Including comprehensive tutorials and clearer instructions would likely enhance the initial user experience and reduce the confusion observed in this study.

Exploring different VR setups, such as those with adjustable screen distances and more comfortable headsets, could help mitigate the physical discomfort reported by users. Incorporating user feedback into the game design process is crucial for addressing the specific issues identified and improving the overall usability and immersion of the game.

By addressing these recommendations, future research can provide more robust insights into the usability of VR applications and contribute to the development of more user-friendly and immersive VR experiences.

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5. References

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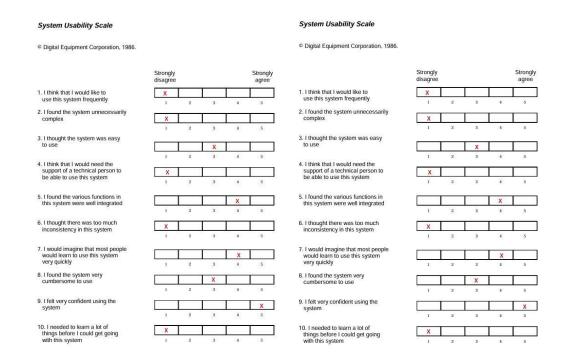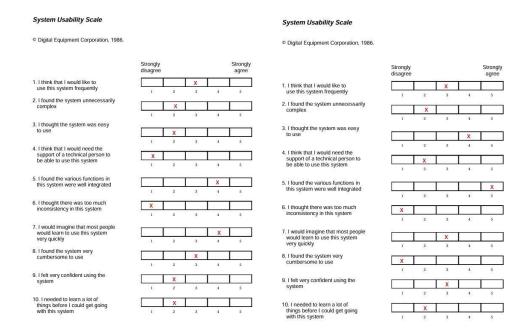**Photos from User Testing Sessions**

Appendices

User Metric Scores:

Appendices 1&2: The SUS Metric scores of Person #1 (left) and Person #2 (right).

Appendices 3&4: The SUS Metric scores of Person #3 (left) and Person #4 (right).

System Usability Scale

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

Appendix 5: The SUS Metric score of Person #5