Analysis of Human Factors and Workloads in Earthquake Disaster Evacuation Simulations Using Virtual Reality Technology

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Abstract. Natural disasters are disasters caused by a series of events caused by nature. An earthquake is an earthquake or event that shakes the earth caused by a collision between the earth's plates, volcanic activity, or the collapse of rocks in a mining area. In a disaster situation, evacuation of knowledge or procedures is very important to optimize the chances of disaster survivors while trying to save themselves. How many migration efforts have been made, for example through direct simulations, as well as print media facilities such as disaster response books, videos, etc. One technology that can make a scenario as if real is virtual reality (VR). VR can be used as a technology when carrying out disaster evacuation simulations to avoid or reduce risk when conducting live simulations. In this study will calculate the workload when using simulations using the SIM-TLX method with several conditions, cybersickness symptoms felt by participants, usability, and immersive in simulation applications. This research was conducted on participants who are experts in disaster response and amateur participants. the results of this study can be seen that the workload does not affect in all five conditions, about 60.42% of participants experienced headaches due to the use of VR, the SUS score obtained was 68.39 out of 100 and a PQ score of 3.95 out of 5.00 which means above average.

1. Introduction
Disasters are events caused by nature or human negligence. Earthquakes, floods, landslides, tidal waves, tornadoes, droughts, volcanic eruptions are natural disasters. An earthquake is an event that shakes the earth caused by a collision between the earth's plates, faults, volcanoes, or the collapse of rocks [1]. Earthquakes are events that can occur at any time and cannot be avoided. This natural disaster can arise at any time that has a negative impact or a very large loss, such as damage to roads, bridges, damage to buildings, bridges, and even paralysis of life activities in an instant. To minimize the risk of impacts due to natural disasters, evacuation education from oneself is needed as an anticipation, because natural disasters are unavoidable events but at least can reduce the risk of their impacts.

The National Disaster Management Agency (BNPB), an Indonesian government agency whose job is prevent and deal with disasters, has tried to provide knowledge and insight to the community so that they are always ready to face disasters in various forms of direction, direct training simulations, as well as through print media and electronic multimedia. Media created by BNPB include printed /
electronic books, and animated disaster response videos which can be viewed through the BNPB Indonesia YouTube site. Technology should be used when running earthquake simulations, which can resemble real conditions in order to reduce risk when running simulations directly. One of the activities that can be done directly on location with the scenario as if he was in a natural disaster situation using the VR application. Virtual Reality (VR) is technology that makes presentations of real-world situations or environments that are simulated in 3D by a computer. Uses that interact using special devices [2-5]. The use of VR is done to analyze the cases we want to discuss, one of which is how to evacuate when an earthquake occurs. In studies using VR simulators, human factors are also very influential, where these human factors are human behavior and human performance.

Psychology views human behavior as a reaction that can be simple and complex but also unique, different from one another [6]. Whereas human performance is a measure of human ability to complete work [7]. The term human performance has become increasingly common in recent years in a number of industries, especially those with a safety focus. Where human performance is often associated with human factors, or even used as a substitute term [8]. Human behavior is one of the determinants of human safety during emergencies. Finding ways and the choice of route to get out is the type of human behavior that is most studied during emergencies. With information about human behavior and performance information when facing this event, it can be a reference in seeing how effective it is in the safety aspect.

Virtual reality applications offer many functions in their applications, one of which is related to virtual disaster simulation. The importance of conducting virtual simulations to minimize unexpected events on the ground and provide disaster preparedness education and training early on for the community and reduce the impact of panic during disasters is an important reason for researchers to make this case study important to research. VR application for natural disasters namely Earthquake Simulator. So, in research using VR, it can also be noted in a person's workload when running a simulation. SIM-TLX is the development of methods that can be done for the measurement of workload in simulations. In this research, we want to know the human factor and measure the level of workload when doing simulations using the SIM-TLX method, find out the cybersickness symptoms felt by participants, calculate the level of usability and presence in the application.

2. Literature Review

2.1. Virtual Reality

Virtual Reality (VR) is a technology to create a simulation environment that allows users to be able to interact with the 3D world by simulating the senses, such as sight, hearing, touch, even smell, but is limited to the availability of content and computing power [9]. In this research, the type of head-mounted devices (HMD) used is Oculus Rift. In terms of evaluation, virtual reality can be a good alternative for real-life testing. Simulation results will be more trusted if virtual reality can provide a better representation of the real world [10]. HMD Oculus Rift shown in figure 1.

![HMD Oculus Rift](image1)

Figure 1. HMD Oculus Rift

2.2. SIM-TLX

The Simulation Task Load Index (SIM-TLX) is designed to maintain a similar overall structure, but to make it more applicable to simulated environmental demands. The scale was developed by selecting relevant items from existing instruments and adding certain simulation scales [11]. SIM-TLX is a
development of NASA-TLX [12] and SURG-TLX [13]. This new scale, adopting the dimensions of mental, physical, temporal, and frustrating demands from NASA-TLX because it is still very applicable for VR simulations. In addition, dimensions of complexity, pressure, and interference are added from special operating versions (SURG-TLX), such as captured load sources that do not exist on NASA-TLX. Additionally, new items are added specifically for workloads in the simulation. As discussed earlier, VR poses challenges in terms of the demands of perception and the demands of environmental control. Therefore, the perception scale and task control were added to overcome this problem, using the same format from the original NASA version. Finally, the scale associated with attendance was added, because the feeling of being present in cyberspace was an important part of the usefulness and training of VR effectiveness. In general, immersive refers to the ability of technology to produce a simulated environment, while presence refers to the feeling of being there created by technology [14]. Therefore, the dimensions used for SIM-TLX are [11]:

- Mental Demands - How exhausting is the task mentally?
- Physical Demands - How physically tiring a task?
- Temporal Claims - How rushed were you during the assignment?
- Frustration - How do you feel insecure, discouraged, annoyed, or stressed?
- Task Complexity - How complex are the tasks?
- Situational Stress - How much stress do you feel when doing a task?
- Distraction - How disruptive is the task environment?
- Perceptual Strains - How uncomfortable or disturbing are the visual and hearing aspects of the task?
- Task Control - How difficult is the task to control / navigate?
- Presence - How immersed are your feelings in your job?

2.3. Cybersickness

Cybersickness is a symptom of discomfort obtained from VR exposure. Images of cybersickness that occur include abdominal awareness, belching, salivation, drowsiness, nausea, headaches, difficulty moving, vision difficulties, eye difficulties, etc. These symptoms are undesirable side effects of psychophysiological exposure to Virtual Environments (VE’s) use which can occur during and after use [15]. Data were collected using the Simulator Sickness Questionnaire (SSQ) item. SSQ consists of 16 questions that allow analysis through disease simulator measurements from various perspectives. Each question comes from the results of various experiments regarding the effects of simulators and can be implemented on the interaction methods used in VR applications. Each category can be calculated with a value between 0 to 3 which is then calculated. The method used to evaluate and reduce disease simulators to find out more potential effects such as age, gender, and others. SSQ Items shown in figure 2.
2.4. Usability

Usability is a product attribute that affects software quality. There are 4 important characteristics of usability, namely attitude, efficiency, effectiveness, flexibility, ability, or ease of learning [16]. In the sense that reusability can be used to measure the level of usability/reusability of a system or equipment. Usability is the level of usability of a product that can be used by users to achieve the goals specified effectively, efficiently, and provide satisfaction [17]. One method that can be used to evaluate the usefulness of a website or application is the System Usability Scale (SUS).

The System Usability Scale (SUS) is one of the user test methods that provide reliable "fast and dirty" measuring instruments. This method was introduced by John Brooke in 1986 [18] who evaluated various types of products or services, including mobile devices, internet site, and applications. SUS is a usability assessment method that provides adequate results based on small sample size, time, and cost. The results of calculations using the SUS method will be used to assess, which can be used to assess, determine, whether feasible or feasible to apply [19]. The SUS items consisted of 10 questions shown in figure 3.

| SSQ items             | Likert Scale |
|-----------------------|--------------|
| General Discomfort    |              |
| Fatigue               |              |
| Headache              |              |
| Eyestrain             |              |
| Difficulty Focusing    |              |
| Increased Salivation  |              |
| Sweating              |              |
| Nausea                |              |
| Difficulty Concentration|            |
| Fullness of Head      |              |
| Blurred Vision        |              |
| Dizziness (eye open)  |              |
| Dizziness (eye closed)|              |
| Vertigo               |              |
| Stomach Awareness     |              |
| Burping               |              |

Figure 2. Simulator Sickness Questionnaire (SSQ) items
2.5. Presence

Presence is a person's psychological feelings in an environment that can involve feelings, concerns, and active involvement that can be done by humans. The environment in which humans are present can be tangible, virtual, symbolic, or a combination of the three. The level of attendance in the environment is influenced by component accuracy (interface quality), natural interactions and activities (loyalty), focus and attention (involvement), ease of adaptation (immersion) and prior human experience [20]. Presence Questionnaire (PQ) consisted of 18 questions shown in figure 4.

| Presence Factor | Question |
|-----------------|----------|
| Involvement     | How much were you able to control events? |
|                 | How responsive was the environment to actions that you initiated (or performed)? |
|                 | How natural did your interactions with the environment seem? |
|                 | How much did the visual aspects of the environment involve you? |
|                 | How natural was the mechanism which controlled movement through the environment? |
|                 | How compelling was your sense of objects moving through space? |
|                 | How much did your experiences in the virtual environment seem consistent with your real world experiences? |
|                 | How compelling was your sense of moving around inside the virtual environment? |
| Fidelity        | How much did the auditory aspects of the environment involve you? |
|                 | How well could you identify sounds? |
|                 | How well could you localize sounds? |
| Immersion       | How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform these tasks or activities? |
|                 | How completely were your senses engaged in this experience? |
|                 | Were there moments during the virtual environment experience when you felt completely focused on the task or environment? |
|                 | How easily did you adjust to the control devices used to interact with the virtual environment? |
| Interface Quality | How much delay did you experience between your actions and expected outcomes? |
|                 | How much did the visual display quality interfere or distract you from performing assigned tasks or required activities? |
|                 | How much did the control devices interfere with the performance of assigned tasks or with |

Figure 3. System Usability Scale (SUS)

Figure 4. Presence Questionnaire (PQ)

3. Method

3.1. Device

The HMD used is Oculus Rift. The gamepad used is the Oculus Rift controller with two joysticks used for navigation and when touching objects. The VR disaster simulation application used for this experiment was obtained from the purchase of the STEAM application, which is an application that
provides games that can be played using both VR or non-VR. The appearance of the VR disaster simulation application is shown in figure 5.

![VR disaster simulation application](image)

**Figure 5.** Capture disaster simulation from STEAM application

3.2. Participant
The sample consisted of 24 men and 24 women aged between 21 and 50 years. the average age of 32.7 years, with a median value of 33 and a mode value of 21. No participant has played VR games before.

3.3. User Task and Procedure
In the experiment assignment, participants performed 3 tasks: (1) Preparing emergency equipment, (2) Shelter under the table when an earthquake occurs, and (3) Leave the room immediately when earthquake has stopped. In the first stage, participants are asked to read and sign the form (which asks for their name, age and gender). After that, the participants were given a briefing about the facilities used and the training procedures. Participants will conduct a trial before experimenting. After completing the task, participants were asked to fill in a questionnaire related to SIM-TLX using five conditions (control, multitasking, time restriction, stress, and disruption), a questionnaire related to the symptoms of cybersickness due to exposure when using VR with the Simulator Sickness Questionnaire (SSQ), questionnaire related to usability simulation application using System Usability Scale (SUS) and questionnaire related to immersive using Presence Questionnaire (PQ).

4. Results and Discussion

4.1. Results SIM-TLX
In conducting simulations using VR technology, it is also important to measure the level of workload using the SIM-TLX. The workload measurement in this simulation uses five conditions used, these conditions are:
- Control – participant was instructed to play the game.
- Multitasking – participant is asked to count down.
- Time restriction – participant is asked to play the game for only 5 minutes.
- Stress – participant was read script designed to induce social evaluative pressure.
- Disruption – participant played the game, but with a degraded visual display and impaired use of the controllers (a plastic insert was placed into the headset to reduce visual acuity and degrade the display, and the controllers were fixed to the users hand to restrict movement, so had to be used in an inverted orientation, which made control more difficult).
Mental demand increases when the VR task is equipped with additional calculations, physical demand increases when the use of a VR device is interrupted, temporal demand were notably increased in the time restriction condition, because in this condition participants will be made aware of the deadline. Increased frustration in disruption conditions due to interference in the use of VR tools. Stress increases in stress and multitasking. Distraction is influenced by multitasking and disruption. Perceptual strain increases under conditions of disruption. Task control and presence are affected by control conditions. The workload comparison can be shown in table 1 and figure 6.

**Table 1. Comparison of Conditions Between Workload**

| Conditions     | Workload |              |              |              |              |              |              |
|----------------|----------|--------------|--------------|--------------|--------------|--------------|--------------|
|                | Mental   | Physical     | Temporal     | Frustration  | Task         | Situational  | Distraction  |
| Control        | Demand   | Demand       | Demand       |              | Complexity   | Stress        |              |
| Multitasking   | ✓        | ✓            | ✓            | ✓            |              |              |              |
| Time Restriction| ✓        |              |              |              |              |              |              |
| Stress         | ✓        |              |              |              |              |              |              |
| Disruption     | ✓        | ✓            | ✓            | ✓            | ✓            |              |              |
| F value        | 1.483    | 1.953        | 1.164        | 2.996        | 2.781        | 2.131        | 2.486        |
| P              | 0.001    |              |              |              |              |              |              |

(a) Mental Demand

(b) Physical Demand

(c) Temporal Demand

(d) Frustration

(e) Task Complexity

(f) Situation Stress
4.1.1. Mental demands. Analysis of variance revealed a significant main effect for the conditions on mental demand, $F(5,251) = 1.483$, $P < 0.001$. With the Bonferroni follow-up test revealed that the multitasking condition was considered to be significantly more complex than the other conditions (see Table 1) with a result of 87.54%, mental demand increased when assignments in VR were supplemented with countdowns / additional mathematical tasks.

4.1.2. Physical demands. Analysis of variance revealed a significant main effect for the condition on physical demand, $F(5,251) = 1.953$, $P < .001$. Bonferroni follow-up tests revealed that the disruption condition was perceived to be significantly more complex than any other condition (see Table 1) with a result of 60.91%, physical demand increases when the use of joystick and headset is interrupted.

4.1.3. Temporal demands. Analysis of variance revealed a significant main effect for the condition on temporal demand, $F(5,251) = 1.164$, $P < .001$. Bonferroni follow-up tests revealed that the time restriction condition was perceived to be significantly more complex than any other condition (see Table 1) with a result of 52.12%, because in this condition participants are made aware of time.

4.1.4. Frustration. Analysis of variance revealed a significant main effect for the condition on frustration, $F(5,251) = 2.996$, $P < .001$. Bonferroni follow-up tests revealed that the disruption condition was perceived to be significantly more complex than any other condition (see Table 1) with a result of 71.91%, because this condition makes participants experience a lot of frustration due to interference in the use of VR tools.

Figure 6. Mean workload (And 95% CL’s) for experimental conditions for all scales of the SIM-TLX.
4.1.5. Task complexity. Analysis of variance revealed a significant main effect for the condition on task complexity, $F(5, 251) = 2.781, P<.001$. Bonferroni follow-up tests revealed that the multitasking condition was perceived to be significantly more complex than any other condition (see table 1) with a result of 59.02%.

4.1.6. Situational Stress. Analysis of variance revealed a significant main effect for the condition on situational stress, $F(5, 251) = 2.131, P<.001$. Bonferroni follow-up tests revealed that the multitasking and stress condition was perceived to be significantly more complex than any other condition (see table 1) with a result of 61.87% and 60.76%.

4.1.7. Distraction. Analysis of variance revealed a significant main effect for the condition on distraction, $F(5, 251) = 2.486, P<.001$. Bonferroni follow-up tests revealed that the disruption and multitasking condition was perceived to be significantly more complex than any other condition (see table 1) with a result of 30.87 and 30.65, because these conditions are limited by the space and interference of the VR device and by counting down.

4.1.8. Perceptual strain. Analysis of variance revealed a significant main effect for the condition on perceptual strain, $F(5, 251) = 2.131, P<.001$. Bonferroni follow-up tests revealed that the disruption condition was perceived to be significantly more complex than any other condition (see table 1) with a result of 40.87%, because of discomfort in the visual and auditory aspects when they do simulations.

4.1.9. Task control. Analysis of variance revealed a significant main effect for the condition on task control, $F(5, 251) = 3.073, P<.001$. Bonferroni follow-up tests revealed that the control condition was perceived to be significantly more complex than any other condition (see table 1) with a result of 78.87%.

4.1.10. Presence/Immersive. Analysis of variance revealed a significant main effect for the condition presence/immersive, $F(5, 251) = 3.073, P<.001$. Bonferroni follow-up tests revealed that the control condition was perceived to be significantly more complex than any other condition (see table 1) with a result of 60.87%.

4.2. Results Cybersickness
After conducting the simulation, a cybersickness questionnaire was given to the participants so that they could find out what symptoms occurred during the use of VR. This questionnaire aims to determine the effect of the effects of real scenarios on the human condition during a disaster. Subjectively, participants gave a Sickness Questionnaire (SSQ) assessment with slight, moderate, and severe. Three classes will affect the final grade, slight weight of 7.58, moderate with a weight of 9.54, and severe having a weight of 13.92.

| SSQ Items          | Likert Scale |
|--------------------|--------------|
|                    | Slight | Moderate | Severe |
| General Discomfort | 14     | 7        | 5      |
| Fatigue            | 12     | 5        | 1      |
| Headache           | 19     | 2        | 8      |
| Eyestrain          | 9      | 9        | 2      |
| Difficulty Focusing| 10     | 7        | 3      |
| Increased Salivation| 1    | 0        | 0      |
| Sweating           | 9      | 6        | 3      |
The most common problems were mild symptoms with a total of 166 occurring in all participants, and facts that had a frequency greater than severe facts or experienced severe symptoms with a total frequency of 38 in all participants. Next will be explained data related to the sequence that has been done by participants during the simulation.

Table 3. Cybersickness symptom ranking on earthquake simulations

| SSQ Items                  | Total | Percentage |
|----------------------------|-------|------------|
| Headache                   | 29    | 60.42%     |
| General discomfort         | 26    | 54.17%     |
| Nausea                     | 25    | 52.08%     |
| Blurred vision             | 24    | 50.00%     |
| Dizziness (eye open)       | 23    | 47.92%     |
| Difficulty concentrating   | 20    | 41.67%     |
| Fullness of head           |       |            |
| Eyestrain                  |       |            |
| Difficulty Focusing        |       |            |
| Dizziness (eye closed)     |       |            |
| Stomach Awareness          | 19    | 39.58%     |
| Fatigue                    | 18    | 37.50%     |
| Sweating                   |       |            |
| Vertigo                    | 2     | 4.17%      |
| Belching                   |       |            |
| Saliva                     | 1     | 2.08%      |

Table 3 shows all the symptoms that can be concluded with cybersickness. Participants at the time of doing the simulation, cybersickness symptoms that most often appear were participants feeling dizzy, experienced by 29 of 48 participants or about 60.42% and followed by symptoms of discomfort and nausea in the second sequence, respectively 26 of 48 participants or approximately 54.17%. As for symptoms that were rarely encountered during the simulation, symptoms of increased saliva were only one participant out of 48 participants or 2.08% during the simulation.
In the simulation, cybersickness is a side effect of the use of VR that occurs in participants, this is caused by the effect of image projections by VR and is not well received by the participants' sense of sight. Based on the results of the data above it is known that the symptoms of headaches are more felt by participants after the use of a VR device. Symptoms of headaches that arise may be due to movements made to see the surrounding area, with visual results from VR less accepted by participants who are not familiar with the use of VR.

4.3. Usability
In this sub-chapter, the results of calculations for System Usability Scale (SUS) will be provided. SUS is a method for measuring the level of usefulness for VR simulations. This method consists of 10 questions with odd numbered questions that lead to good usage and even numbered questions that lead to bad usage. 10 questions will be converted from the Likert 1-5 scale to the 1-100 scale.

| The System Usability Scale                                      | Score | Score Conversion | SUS Score |
|----------------------------------------------------------------|-------|------------------|-----------|
| I think that I would like to use this system frequently.       | 4     | 3                |           |
| I found the system unnecessarily complex.                      | 2,71  | 2,29             |           |
| I thought the system was easy to use.                          | 4,04  | 3,04             |           |
| I think that I would need the support of a technical person to be able to use this system. | 2,94  | 2,06             |           |
| I found the various functions in this system were well integrated. | 4,17  | 3,17             |           |
| I thought there was too much inconsistency in this system.     | 2,63  | 2,38             |           |
| I would imagine that most people would learn to use this system very quickly. | 3,98  | 2,98             |           |
| I found the system very cumbersome to use.                     | 1,69  | 3,31             |           |
| I felt very confident using the system.                        | 4,44  | 3,44             |           |
| I needed to learn a lot of things before I could get going with this system. | 3,31  | 1,69             |           |

From the table above, it is clear that the usability level shows 68.39 out of 100. The values are categorized in rank B. This shows that the earthquake simulation application has a pretty good level of use (above average) so that it can be said that this application is user friendly. The condition of this sus score states that the application is easy to learn, efficient in operation, and the user is quite satisfied in using the application.

4.4. Presence Questionnaire
In this section, the calculation results for PQ will be provided. PQ is a method for measuring immersion levels in VR simulations. This method consists of 18 questions after modification. 18 questions were grouped into 4 attendance factors which are involvement, sensory fidelity, immersion/adaptation, and interface quality. PQ calculation results result is given in table 5.
### Table 5. Presence Questionnaire (PQ) Score

| Presence Factor | Question Score | Factor Score | PQ Score |
|-----------------|----------------|--------------|----------|
| Involvement     | 3.75           | 3.9          | 3.95     |
|                 | 3.9            |              |          |
|                 | 3.98           |              |          |
|                 | 4.17           | 3.9          |          |
|                 | 3.75           |              |          |
|                 | 3.67           |              |          |
|                 | 3.96           |              |          |
|                 | 4.04           |              |          |
| Fidelity        | 3.77           |              | 3.95     |
|                 | 3.94           | 3.95         |          |
|                 | 4.15           |              |          |
| Immersion       | 3.98           |              |          |
|                 | 4.1            | 3.95         |          |
|                 | 3.67           |              |          |
|                 | 4.06           |              |          |
| Interface Quality | 3.88         | 3.98        | 4.06     |

Table 5 shows that the simulation got 3.95 from 5.00. This value is quite good or above average. For the involvement factor, the result is 3.90 out of 5.00. For Fidelity 3.95 of the 5.00 results obtained. For the Immersion factor, obtained 3.95 out of 5.00. Finally, the Interface Quality factor obtained 3.98 results from 5.00. An analysis of variance was performed to investigate the influence of demographics on the PQ mean score. Analysis of variance was performed to investigate the effect of demographics on average PQ scores. Survey data shows that participants experience a feeling of good presence in a virtual environment.

### 5. Conclusion

Under conditions that can affect workloads in earthquake simulations, there are significant differences. Mental demand is a more influential multitasking condition with an outcome of 87.54%. Physical demand is a more influential condition with a yield of 60.91%. Temporal demand is a time-limiting condition that is more influential with a yield of 52.12%. frustration is a condition that affects more disorders with a yield of 71.91%. Task complexity is a more influential multitasking condition with a result of 59.01%. Stress with multitasking and stress conditions is more influential with the results of 61.87% and 60.76%. Distraction is a condition of disruption and multitasking that is more influential with the results of 30.87% and 30.65%. Perception strain is a condition that affects more disorders with a yield of 40.87%. Task control is a more influential control condition with 78.87% results, and presence / immersive is a more influential control condition with 60.87% results.

For cybersickness symptoms, participants experienced more headache symptoms or around 60.42% experienced because of the possible effects of image projections by VR and were not well received by the participatory sense of sight. Survey data shows that participants experience a good feeling of

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**Table 5. Presence Questionnaire (PQ) Score**

| Presence Factor | Question Score | Factor Score | PQ Score |
|-----------------|----------------|--------------|----------|
| Involvement     | 3.75           | 3.9          | 3.95     |
|                 | 3.9            |              |          |
|                 | 3.98           |              |          |
|                 | 4.17           | 3.9          |          |
|                 | 3.75           |              |          |
|                 | 3.67           |              |          |
|                 | 3.96           |              |          |
|                 | 4.04           |              |          |
| Fidelity        | 3.77           |              | 3.95     |
|                 | 3.94           | 3.95         |          |
|                 | 4.15           |              |          |
| Immersion       | 3.98           |              |          |
|                 | 4.1            | 3.95         |          |
|                 | 3.67           |              |          |
|                 | 4.06           |              |          |
| Interface Quality | 3.88         | 3.98        | 4.06     |
presence in the environment with a score 3.95. Participants also give a good score of usability in applications with scores 68.39 which is above average. the use of earthquake simulations has many more benefits, one of which is providing education on disaster response in the form of simulations with VR technology and can reduce the risk of dangerous things happening when doing direct simulations.

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