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Analysis of Human Performance and Potential Application of Virtual Reality (VR) Shooting Games as a Shooting Training Simulator for Military Personnel

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Abstract. Shooting is one of the essential abilities that military personnel must regularly train. One technology that can be applied to the military shooting sector is the Virtual Reality (VR) shooting game. This technology is a shooting training simulator for Military Personnel. This study compares the shooting performance of military personnel in both real and virtual environments. The researchers analyzed the learning curve of the shooting performance, measured the degree of reality, immersive level, and usability of the VR shooting games, and tested the potential application of the simulator. The result showed that the shooting accuracy and precision in real and virtual shooting conditions do not significantly differ. This means that using a VR shooting game simulator can represent the training conditions in the actual shooting range. The shooting speed in virtual environments is related to the stages of the shooter (position, breath control, aiming, and trigger control), which are influenced by human performance factors (shock, vibration, and gun explosions). In addition, the shooting performance when practicing virtual shooting increased significantly, proving a learning curve for adapting to virtual environments in the simulator. VR shooting games had a total SUS score of 81.1, categorized as Grade A usability or excellent usability. Based on the results of the Pearson correlation test, there is a strong positive relationship between the SUS questionnaire and Presence Questionnaire (0.908), SUS and Immersive Tendencies Questionnaire (0.802), and Presence Questionnaire and Immersive Tendencies Questionnaire (0.814). Good usability in VR shooting games positively influences the degree of reality and can make participants feel a high presence when shooting virtually. Thus, VR shooting games are appropriate to support military shooting training for military personnel.

Keywords: Cognitive; Human Performance; Military Personnel; Shooting Training; Virtual Reality

1. Introduction

Shooting is one of the essential abilities that military personnel must regularly train to

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hone their combat instincts and concentration in aiming the targets. The performance of military personnel regarding the accuracy of aiming the targets can be continuously increased until stable if the frequency of shooting practice is high. The accuracy of the shooting results is related to the stability of the gun in the shooter, which is influenced by hormonal factors, muscle temperature, and frequency of training that has been carried out (Pallegrini and Schena, 2006). It is also supported by research conducted by Goonetilleke, Hoffmann, and Lau (2009), which stated that the shooter's experience affects shooting performance, which is evaluated based on the results of shooting accuracy and precision. Thus, shooting performance is affected by the frequency of training and experience of the shooter. However, routine conventional shooting training for military personnel is impeded by the high costs associated with training and ammunition. In addition, the calculation of the results of the accuracy of hitting bullets to the shooting target is still performed manually. Therefore, there is an element of subjectivity in assessing the shots' results.

The new digital platform technology trend has penetrated the education and training sector to increase accessibility, communication, and satisfaction (Koroleva and Kuratova, 2020). Technology that can be applied to the military sector, especially shooting training, is Virtual Reality (VR). VR is a technology designed to perform virtual simulations that allow users to interact with 3D environments through human senses, such as sight, hearing, touch and smell (Bardi, 2019). According to Kalarat and Koomhin (2019), VR displays an artificial environment that can affect the user's haptic, auditory, and visual senses. VR technology can accommodate complex experiments that can be carried out in the laboratory. The implementation of VR as a computer-stimulated virtual laboratory can provide users with adequate understanding and experience (Oyewola *et al.,* 2021). Consequently, the researchers do not need to research the field directly, which is highly risky and is limited by various factors (Cipresso *et al.,* 2018). VR is a form of future educational media development with features that adapt the real world to become virtual (Unity, 2020). Virtual Reality can be classified as ICT (Information and Communication Technology) in education, which is widely used as a supporting device for knowledge transfer and interactive learning (Godin and Terekhova, 2021). Globally, VR technology has been developed to solve problems in various sectors, one of which is used as a training facility. According to Siriborvornratanakul (2016), VR technology is used for multichannel communication between the headset dan the user regarding heart rate monitoring. The technology is implemented as interactive coaching in the context of fitness and rehabilitation purposes (Hulsmann, Kopp, and Botsch, 2017). Based on the data from Goldman Sachs Global Investment Research (2019) related to the VR technology application sectors in 2020 and 2025, there are 9 (nine) market segments of VR technology, namely video games, health care, engineering, live events, video entertainment, real estate, retail, military, and education. The VR technology application segment in the military industry is the second lowest, with a projected market size of 1.4 billion US dollars in 2025. It proves that there are potential research opportunities for applying VR technology in the military sector as an education and training facility.

An example of the application of Virtual Reality technology for military education purposes is its function as a facility for military war simulations so that all personnel can experience the real conditions of war. In addition, VR is also developed as a therapeutic tool for military personnel who have experienced trauma or stress (Rizzo *et al.,* 2005). Then, VR technology also has an essential role in the military sector in training the emotions and experience of its personnel. For example, VR has been used as a training facility for coordination and communication between military personnel in a rescue mission (Kozlak, Nawrat, and Kurzeja, 2014). In addition, the technology can be used in non-physical training, such as tactical missions, operational missions, and teamwork (Lele, 2013). However, of all the research conducted, no research has been discovered related to specific VR technology to train precise shooting dexterity.

The application of Virtual Reality technology as an alternative facility for training shooting dexterity is linked to the shooter's cognition in adjusting to the virtual shooting practice conditions. Cognitive aspects can be reviewed based on shooting performance related to 4 technical factors: position, breath control, aiming, and trigger control (Ihalainen *et al.,* 2015). Shooting activities using firearms are classified as dynamic movements that involve a biomechanical system between the shooter and the weapon used (Fedaravicius *et al.,* 2019). In the use of firearms, there is a shock that affects the shooter's accuracy as a result of the explosion of the bullet that is fired (Hall, 2008). The measurements of shooting performance are based on the results of the shots, i.e., accuracy, precision, and the number of on-target shots (Brown and Mitchell, 2017). Based on Liu and Mao (2000), a shooter is said to have good shooting performance if they can control the body position, aim at targets, and shoot serenity (trigger control). Apart from the technical factors, shooting performance can be affected by the virtual environment that the shooter perceives. Shooter interactions with virtual environments in virtual shooting technology can be measured using the Presence Questionnaire (PQ), Immersive Tendencies Questionnaire (ITQ), and System Usability Scale (SUS). PQ is used to determine the player's assessment regarding the level or degree of reality of a virtual environment compared to the real conditions (Witmer, Jerome, and Singer, 2005). Then, the ITQ is used to assess how immersive a person is in the virtual environment to real conditions (Witmer and Singer, 1998). ITQ consists of 3 subscales: Involvement, focus, and the tendency to play and enjoy video games (Jerome and Witmer, 2002). The ITQ questionnaire has a relationship with the PQ questionnaire. A strong correlation between the PQ score and the ITQ score indicates that an individual has experienced a "high presence" in the virtual environment (Johns *et al.,* 2000). Meanwhile, the SUS questionnaire is utilized to measure the quality, ease of use, and convenience of technology or systems (Sauro and Lewis, 2011).

This paper attempts to propose a VR shooting game to train shooters in the military education sector. The VR shooting game is equipped with a handgun with the same mass as the SIG Sauer P226. This type of pistol is the standard shooting equipment used by the military in Indonesia. Shooting training education using VR shooting games has no time and place restrictions and is free of ammunition procurement fees. Therefore, it is anticipated that military personnel can enhance their training frequency, leading to an improvement in their shooting dexterity. This research analyzes the cognitive aspects of shooting performance based on the shooting parameters (shooting accuracy, precision, and duration) to review the shooter's adaptation to the virtual shooting method using VR shooting game technology. Furthermore, measurements of the degree of reality, immersive level, and usability of VR shooting games were carried out. Finally, this research was conducted to review and analyze the feasibility of VR shooting games to support conventional shooting training.

2. Methods

The research scenario design is in accordance with the design of experiments, which is classified as a quasi-experimental design with a counterbalanced design type. The independent variables in this study were environmental conditions (real, virtual) and the types of participants (regular, expert). Then, there were three dependent variables: shooting accuracy, shooting precision, and shooting duration. Accuracy is the proximity value measured against a predetermined standard value. At the same time, precision is the value of the proximity between one measurement result and another on a repeated measurement (Mccarthy, 2017). Accuracy is obtained based on the shooting results or the bullet's impact on the target, while precision is obtained from the standard deviation.

Figure 1 Apparatus and Virtual Environments of VR Shooting Game

In the quasi-experimental design with counterbalanced design (Montgomery, 2017), the participants, consisting of the regular shooters and expert shooters carried out the entire shooting environmental conditions (real and virtual), which were grouped according to the basic knowledge, shooting experience, and total shooting accuracy results when the real experiment took place. The participants were military personnel in Indonesia. The expert shooter category is randomly selected from a military firing squad with special qualifications or national military certification. In contrast, the regular shooter category is selected from soldiers still in training to get a shooting certification. Each participant would repeatedly carry out shooting activities using the VR shooting games for five rounds to determine the increase in shooting accuracy and precision. This study involved 24 participants who were divided into 12 regular shooters and 12 expert shooters. The designation of the number of participants considered the concept of balanced design based on the predetermined research variables. The participants were male military personnel aged 26-42 years (mean of 29.83 years and SD of 4.02). All participants met the criteria for normal vision based on the results of a vision screening test consisting of visual acuity, contrast vision, and color vision check using Zeiss Online Vision Screening (Zeiss International, 2017). The apparatus used in the real shooting experiment was a handgun, shooting targets, a stopwatch, and 9 mm bullets, while in virtual shooting experiments using a VR shooting game simulator consisted of a prototype gun, a Head-Mounted Display (HMD), a mini-PC, speakers, and a television. Due to anthropometry being an important factor to consider during the design process of equipment or facilities, the VR shooting game apparatus was designed considering Indonesian anthropometry, which represents the standard body and hand dimensions for Indonesian people (Widyanti *et al.*, 2015). However, variations in body dimensions among people, between the sexes, and among different races can make product design problematic (Chuan, Hartono, and Kumar, 2010). In measuring the degree of reality, immersive level, and usability of the VR shooting game, each participant who finished shooting virtually would be given three types of questionnaires filled out online, i.e. Presence Questionnaire (PQ), Immersive Tendencies Questionnaire (ITQ), and System Usability Scale (SUS) questionnaire In addition to completing the PQ, ITQ, and SUS questionnaires, participants would also respond to open-ended questions and undergo in-depth interviews for qualitative analysis of shooting performance.

3. Results and Discussion

This research compares conventional (real) shooting practice with virtual shooting using VR shooting games. In addition, the participants' adjustment to the virtual shooting environment was also analyzed based on changes in the accuracy (mean) and precision (standard deviation) of each shooting round that had been carried out.

Table 1 ANOVA test results

Metric	Regular vs Expert		Real vs Virtual	
	F-Test	P Value	F-Test	P Value
Shooting Accuracy	6243.315	0.000*	0.585	0.449
Shooting Precision	1748.185	0.000*	0.608	0.440
Shooting Duration	0.838	0.365	890.019	0.000*

**The data compared were significantly different (p value < 0.05; F calculate > 4.061)*

In comparing the results of shooting performance based on the types of shooters and environmental conditions, statistical testing was carried out using the MANOVA method using statistical software. According to Tabachnick and Fidell (2007), MANOVA is a generalization of ANOVA used for several dependent variables. The results of statistical tests with the MANOVA method showed that the types of shooters [F (3.42) = 2424.640; p = 0.000] and environmental conditions [F (3.42) = 283.467; p = 0.000] have an influence on the dependent variable. The results of the MANOVA test were continued with the ANOVA method to determine the effect of the types of participants and environmental conditions on shooting accuracy, shooting precision, and shooting duration (Table 1). ANOVA is a statistical analysis technique used to test research hypotheses by assessing the difference in three or more average values of single or multiple factors by comparing the variance between groups and the variance within groups (Gamst, Meyers, and Guarino, 2008). The expert shooters had a higher shooting accuracy (indicated by the acquisition of a shooting score) compared to the regular shooters [F (1.44) = 6241.315; p = 0.000], and there was no significant difference in the results of shooting accuracy in the real shooting practice with the virtual one [F (1.44) = 0.585; p = 0.449]. Then, in the shooting precision parameter, the expert shooters had more precise shots, which were indicated by a decrease in the standard deviation compared to the regular shooters [F (1.44) = 1748.185; p = 0.000], and there was no significant difference in shooting precision results in the real and virtual shooting practices [F (1.44) = 0.608; p = 0.440]. Meanwhile, the results of shooting duration in the real and virtual shooting practices had a significant difference [F (1.44) = 890.019; p = 0.000], where the shooting duration in the virtual shooting practice was faster than in the real shooting practice.

The shooting performance under study encompasses both quantitative aspects, such as accuracy, precision, and shooting duration, as well as qualitative analyses of technical factors at various stages of the shooting process (position, breath control, aiming, trigger control). Shooting accuracy is a measure or value of proximity that is measured against the standard value or main target. At the same time, precision is the value of the closeness between one shot and another (standard deviation) on repeated measurements. In this study, we compared real and virtual shooting performance and examined the shooter's cognitive level in adapting to virtual environments in military shooting. Based on the output of data processing using the MANOVA method, it could be observed that the variables of types of shooters (regular, expert) and environmental conditions (real, virtual) influenced the dependent variables (accuracy, precision, and shooting duration). It was followed by hypothesis testing using the ANOVA method to find out more about the dependent variables influenced by the independent variables. Based on the output of ANOVA data processing

(Table 1), it was determined that there was no significant difference in the accuracy and shooting precision of the real and virtual shooting experiments. The expert shooters had more accurate and precise shots than the regular shooters, which came from both shooting practice conditions. However, the shooting duration in the real and virtual shooting using a VR shooting game had a significant difference. The duration of virtual shooting was proven to be faster (mean: 24 seconds) than the real shooting (mean: 56 seconds). The prototype instrument of the gun influenced the difference in shooting duration used when shooting virtually. The pistol prototype uses the vibration feature on the HMD console so that the vibration, pounding, and explosion sounds are not 100% similar to the actual gun. One of the main factors is that real shooting takes longer than virtual shooting because strong gun vibrations make it necessary for the shooter to adjust the aiming process. Researchers also conducted more in-depth interviews to determine the factors influencing shooting duration. According to the results of interviews with the selected participants, it was identified that the aspects that affected the duration of the shooting were 55% from the stomping and vibration of the gun, 20% from the sound of the gunshot, which could cause the shooter to feel shocked, 15% from the gun pressing and triggering, and 10% from the process of refilling the bullet or recoil. These factors influence the speed of the shooting process duration for the positioning stage, breath control, aiming, and trigger control on the participants when shooting virtually. According to an expert shooter, VR shooting games have virtual environments and shooting stages representing natural conditions. Hence, the technology is suitable as a learning platform for military personnel. Based on this fact, VR shooting games cannot replace the pistol gun sensation. According to Kaber *et al.* (2012), VR simulator design has perceived realism limitations related to graphic latency and haptic renderings. Still, the accuracy and precision parameters of virtual shooting training prove that this technology has a strategic positioning to support existing shooting training.

Shooting is one of the repetitive activities. Consequently, the performance of military personnel regarding the accuracy and precision of shooting can be increased continuously until it is stable if the frequency of shooting practice is high. However, every person or user of new technology needs to adjust to master the technology (Patel *et al.,* 2006). In using VR shooting game simulators for virtual shooting training, shooters need to adapt to the virtual environments and simulators used. The virtual shooting practice adjustment process was realized in the shooting round of each shooter, from now on, called the learning curve of shooting. As the research participants, every personnel involved inevitably needs adjustment and virtual shooting learning using VR shooting games. Therefore, a learning curve analysis is required regarding the shooting performance of each participant to determine the optimal point of mastery of VR shooting games. Researchers determined five iterations for shooting training because we had limited access to real shooting experiments. Referring to Patel *et al.* (2006), the five iterations can represent the learning curve for performance assessment of Carotid Angiography. The learning curve analysis for the shooting was carried out by testing the shooting accuracy and precision results quantitatively and qualitative interviews related to shooting performance. An analysis of the pairwise comparison was performed to determine the significance of the increase in shooting accuracy and the decrease in the standard deviation of each round.

Table 2 Results of repeated measures ANOVA and pairwise comparisons

Metric	Shooter Type	Repeated Measures ANOVA		Pairwise Comparisons			
				Iteration 1 – 3		Iteration 1 –5	
		F-Test	P-Value	Mean Difference	P-Value	Mean Difference	P-Value
Shooting accuracy	Regular	11.253	0.000*	21.917	0.000*	16.200	0.039*
	Expert	18.738	0.000*	21.300	0.000*	14.275	0.016*
Shooting precision (standard deviation)	Regular	2.903	0.032*	0.220	0.015*	0.521	0.540
	Expert	4.626	0.003*	0.202	0.006*	0.274	1.000

**The iteration data compared has a significant increase (p value < 0.05; F calculate > 2.584)*

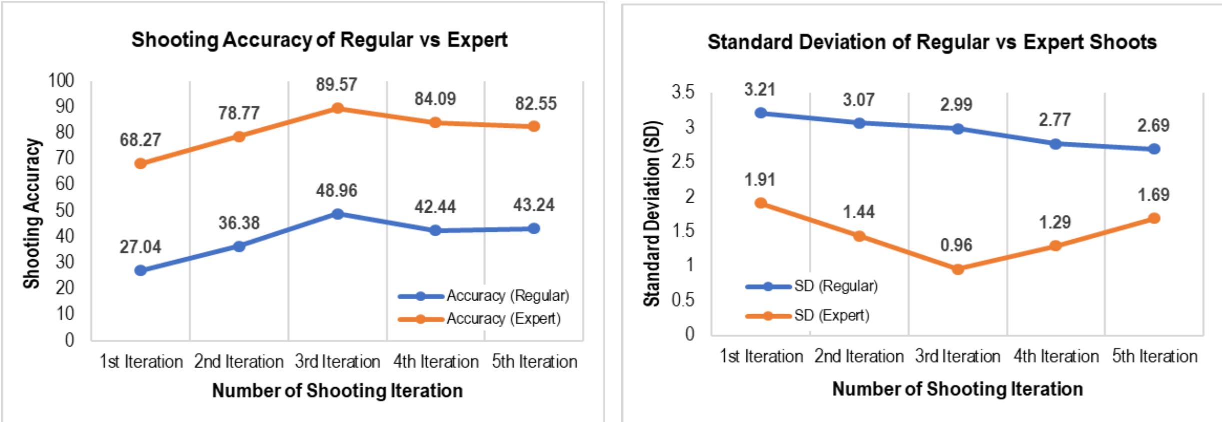

Figure 2 Shooting accuracy and precision for regular and expert shooters (learning curve)

There were two parameters employed to review the learning curve of shooting, namely shooting accuracy and shooting precision. Figure 2 shows the learning curve of shooting in terms of shooting accuracy and precision. According to Pritasari, *et al.* (2013) and Suaib (2011), repeated-measures ANOVA can analyze a research variable that is observed repeatedly at different times or periods. Based on the results (Table 2), there was a significant increase in the accuracy of regular shooters [F (4.44) = 11.253; p = 0.000] and expert shooters [F (4.44) = 18.738; p = 0.000]. On the standard deviation metric, there was a significant reduction in the regular shooters [F (4.44) = 2.903; p = 0.032] and the expert shooters [F (4.44) = 4.626; p = 0.003]. This decrease in standard deviation indicates an increase in shooting precision for both regular and expert shooters.

The learning curve for shooting can be determined based on the increasing accuracy and the decreasing standard deviation of each shooting round. Overall, the shooting accuracy from round 1 to round 5 in the regular shooters (mean difference 16.200) experienced a significant increase (p = 0.039). Likewise, the results of shooting accuracy for the expert shooters increased significantly from round 1 to 5 (mean difference of 14.275) (p = 0.016). However, the shooting accuracy data for rounds 4 and 5 is unstable. It has an insignificant decrease from the round 3 accuracy data. Ideally, the shooting accuracy data will always increase along with the increasing shooting rounds. In addition, the standard deviation from round 1 to round 5 for the regular shooters (mean difference of 0.521) did not result in a significant decrease (p = 0.540). However, there was a significant decrease in the standard deviation (p = 0.015) from round 1 to round 3 (mean difference of 0.220). In the standard deviation data for the expert shooters from round 1 to round 5 (mean difference of 0.274), there was no significant decrease (p = 1,000), either. However, there was a significant decrease in the standard deviation of expert shooters from round 1 to round 3 (mean difference of 0.202) (p = 0.006). As with the accuracy data, the standard deviation data for rounds 4 and 5 for the expert shooters experienced an insignificant increase from the round 3 data. Ideally, the standard deviation data will decrease as the shooting round increases. Thus, the standard deviation data for both the regular and expert shooters has decreased significantly in round 1 to round 3 and is stable up to round 5. This condition also occurred in a study by Patel *et al.* (2006) that measured the learning curve of cardiologists in adjusting the Carotid Angiography Simulator. This indicates a learning curve for shooting regarding the shooting accuracy metrics and standard deviation.

Based on the results obtained, all shooters could customize the virtual environments for virtual shooting activities using a VR shooting game in the third round. However, most participants experienced fatigue and disturbed concentration during the shooting activity in rounds 4 and 5. It could be proven by the absence of an increase in the shooting accuracy and the emergence of a decrease in the standard deviation of shooting, which was not significant in the last two rounds. The results of shooting accuracy and precision from virtual shooting in 5 rounds using a VR shooting game showed that shooters with high accuracy values did not guarantee high precision and vice versa. In other words, accuracy and precision were independent or unrelated (Mccarthy, 2017). For example, one expert shooter had a total shooting accuracy of 90.60 (the highest accuracy value of all participants) and 0.852 shooting precision. Another expert shooter had a total shooting accuracy of 89.60 with a shooting precision of 0.767. It is related to shooting performance and the factors that influence it.

Table 3 Output of correlation test results with Pearson correlation

	Metric	SUS	PQ	ITQ
SUS	Pearson Correlation	1	0.908***	0.802**
	Sig. 2 Tailed		0.000	0.000
PQ	Pearson Correlation	0.908***	1	0.814**
	Sig. 2 Tailed	0.000		0.000
ITQ	Pearson Correlation	0.802**	0.814**	1
	Sig. 2 Tailed	0.000	0.000	

**The iteration data compared had a significant increase (p value < 0.05), **Had a strong correlation (0.70 – 0.89), ***Had a very strong correlation (0.90 – 1.00)*

This study measured the usability of VR shooting games and the degree of reality and immersive level of the shooters when doing virtual shooting training. Table 3 shows the results of the System Usability Scale (SUS), Presence Questionnaire (PQ), and Immersive Tendencies Questionnaire (ITQ) questionnaire correlation tests using Pearson Product Moment. According to Schober, Boer, and Schwarte (2018), the Pearson Correlation value of 0.70 - 0.89 indicates a strong positive or negative relationship, while the Pearson Correlation value of 0.90 - 1.00 indicates a very strong positive or negative relationship. The results of the SUS and PQ scores had a very strong correlation (p = 0.000) (0.908). Then, the results of the SUS and ITQ scores had a strong correlation (p = 0.000) (0.802). Finally, the PQ and ITQ scores had a strong correlation (p = 0.000) (0.814). The relationship between the results of the SUS (z-axis), PQ (y-axis), and ITQ (x-axis) questionnaires could be described by a 3D scatter plot, which was then converted into a 3D SUS-PQ-ITQ matrix model (Figure 2).

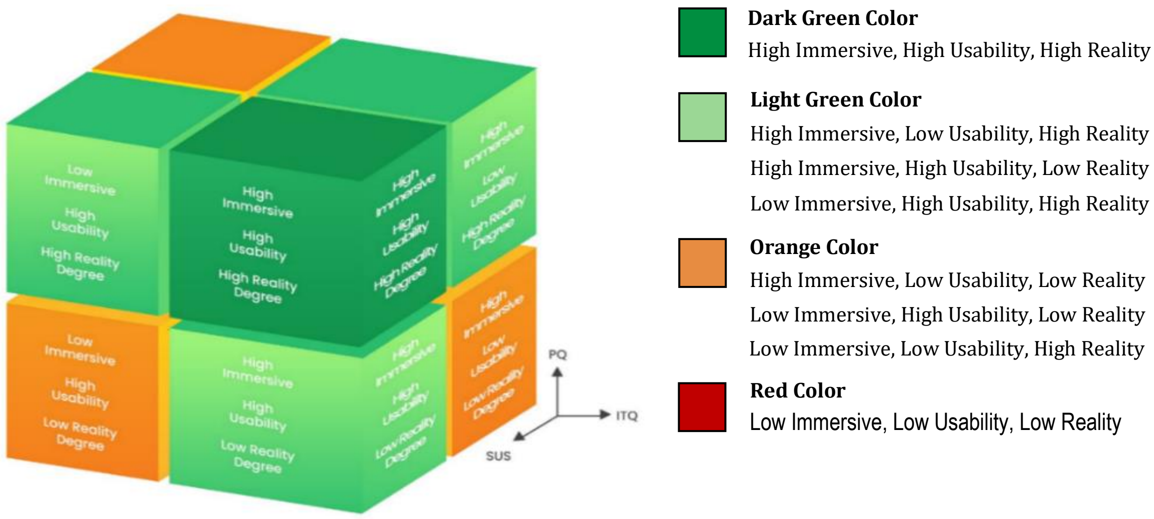

Figure 3 3D SUS-PQ-ITQ Matrix from ITQ Questionnaire (X-axis), PQ (Y-axis), SUS (Z-axis)

The results of the SUS questionnaire yielded an average total score of 81.1, indicating very good usability according to the Sauro and Lewis (2011) SUS Scoring Matrix, placing it in the Grade A usability category. Furthermore, the total mean PQ score was 136.58 out of 160 (high reality), and the total average ITQ score was 74.79 from 90 (high immersive). In determining the degree of relationship between the results of the SUS, PQ, and ITQ questionnaires from the participant's assessment of the VR shooting game, a Pearson Product Moment correlation test was performed using statistical software (Table 3). The correlation test results between SUS and PQ found that the SUS and PQ scores had a very strong positive relationship. In addition, the SUS and ITQ correlation test showed that the SUS and ITQ scores had a strong positive relationship. Finally, the correlation test between PQ and ITQ shows that the PQ and ITQ scores also have a strong positive relationship. According to the research conducted by Johns *et al.* (2000), if the PQ score has a strong correlation with the ITQ score, it can be concluded that the user feels a high presence in the virtual environment.

The three questionnaires were combined and visualized with the 3D SUS-PQ-ITQ Matrix (Figure 3). There were eight blocks with four color indicators: dark green, light green, orange, and red. The relationship and score results of the three questionnaires are in the dark green blocks, indicating that VR shooting games have high immersive, high usability, and high reality. It means that the SUS, PQ, and ITQ questionnaires have a strong positive relationship and influence each other. VR shooting games have very good usability, which affects the degree of reality in virtual environments; thus, shooters feel highly immersive when shooting virtually. This result could be achieved because the eye health of the shooters influences it. The whole shooter had normal vision, as evidenced by passing the vision screening test. In addition, the shooter feels ergonomics to use the VR shooting game because it considers the standard body and hand dimensions based on Indonesia Anthropometry Data. Based on the qualitative assessment through in-depth interviews, the participants considered VR shooting games to have a high level of shooting reality, just like shooting training education in real conditions. This result can be achieved because the eye health of the shooters influences it. The whole shooter had normal vision, as evidenced by passing the vision screening test.

The combination of quantitative and qualitative assessment on the potential implementation of VR shooting games can prove that VR shooting games are feasible to be applied as a complement to or support military shooting training. VR shooting games are similar to real shooting practice conditions and are easy to master by new players or users. In addition, this simulator has a high usability and reality level and can make players feel a high presence when shooting virtually. The existence of a VR shooting game simulator can also provide a new experience for participants related to VR-based shooting technology that is not obtained when shooting in reality.

4. Conclusions

The expert participants had more accurate and precise shooting results than the regular participants in environmental conditions, i.e. real and virtual shooting. However, the shooting duration in virtual shooting training education tends to be faster than in real shooting. It is influenced by the shock, vibration, and explosion factors of weapons not available in the pistol prototype. This factor influences the speed of the shooting process duration (position, breath control, aiming, trigger control) in the participants when shooting virtually. The accuracy and shooting precision increased significantly from rounds 1 to 3 and became stable in rounds 4 and 5. These results indicate a learning curve for shooting accuracy and precision for all types of shooters (regular and expert) during virtual shooting experiments. The learning curve for shooting in this study is related to the learning process and mastery of virtual shooting technology using VR shooting games. The VR shooting game had a total SUS score of 81.1, which can be categorized as at the Grade A usability level or very good. Based on the results of the Pearson correlation test, there is a very strong positive relationship between the SUS questionnaire and PQ (0.908) and a strong positive relationship between the SUS questionnaire and ITQ (0.802) and PQ with ITQ (0.814). Good usability in VR shooting games has a positive influence on the degree of reality and can make participants feel a high presence when shooting virtually.

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