UTRECHT UNIVERSITY

MASTER THESIS

From Virtual Bullets to Real Brilliance: The effect of debriefing after VR firearm training

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Abstract

Virtual Reality (VR) is one of the key emerging technologies of this century and can be used in many domains. One of these domains is the education domain, where training in VR has become much more affordable due to the recent rise in the availability and affordability of consumer-grade VR equipment. Training in VR comes with many advantages such as an increase in motivation and an increase in self-efficacy. However, because of the novelty of VR, it is interesting to look into the implementation of the technology within a curriculum. It is important that the implemented VR module stays exciting and effective for the students using the technology. Debriefing is a facilitated phase that triggers reflective thinking after a simulation. Adding debriefing after simulation-based training is beneficial for students according to literature because they get a chance to examine their decision-making process and the consequences. Debriefing also increases performance scores.

The main objective of this research is to look into the effect of debriefing after VR firearm training at the Dutch Police Academy (PA) on knowledge gain, self-efficacy, motivation, and perceived usefulness. Furthermore, the research looks into what the best way of debriefing is for this specific case. The research uses VRange, a VR firearm training module for PA students, and The 3D Model of Debriefing, to conduct the experiment.

46 PA students participated in this study. The participants were divided into three groups; a no-debriefing (ND) group, a self-debriefing (SD) group, and a peer-to-peer (P2P) debriefing group. First, the students filled in a questionnaire, thereafter they would experience the VR training. The SD and P2P groups were debriefed after the VR training. The experiment ended with a post-questionnaire. All quantitative questions are based on existing questionnaires. The pre-questionnaire measures the knowledge and self-efficacy levels before the VR training. The post-questionnaire measures the aforementioned variables plus motivation, perceived usefulness, and, the debriefing experience.

The results and discussion show that there are no significant results that indicate that the debriefing groups outperform the non-debriefed group for the self-efficacy, motivation, and perceived usefulness variables. Looking at the qualitative answers, the SD-group is more content with the debriefing session and the ND-group is most enthusiastic about the idea of debriefing, although they were not debriefed. Therefore, it cannot be concluded that the implementation of VRange would benefit from the addition of debriefing because the effectiveness of adding debriefing cannot be proven by this research.

Although it cannot be concluded that the implementation of VRange would benefit from the addition of debriefing, some recommendations can be made. Debriefing can actually help students to be more reflective and students do see the benefit of debriefing. However, a module like VRange may not be the best educational tool for a debriefing. Another VR simulation, with less procedural knowledge, but where students need to make more choices could benefit more from the implementation of debriefing. If debriefing was to be used without a facilitator, self-debriefing would fit the Police Academy best. Because learners can track their progress individually and take it more seriously.

Keywords: ***VR training • Debriefing • Self-debriefing • Group-debriefing • VR in education • Adult education***

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Chapter 1

Introduction

Virtual Reality (VR) is booming; VR that utilises head-mounted displays (HMD) is one of the key emerging technologies of this century. The technology has drawn the attention of consumers, practitioners, and scholars in various disciplines [14]. Although VR has been known for decades, the recent rise in availability and affordability of consumer-grade VR experiences has led to an interest in the capabilities of the technology from different domains [14]. Studying with VR offers an ideal manner to approach, study and remember new knowledge for individuals who prefer a visual, auditory, or kinaesthetic learning style [18].

The Dutch Police Academy (PA) provides training, knowledge, and research for the Dutch national police. The PA is a dynamic organization; offering training and knowledge programmes of a high standard of quality, anticipating current developments in society and translating these into customised education programmes [1]. One of these current developments is implementing virtual reality as an educational resource within the police training curriculum. The PA realises this vision with the help of their in-house VR development team, which currently develops different VR modules which can be used within the curriculum [52].

VR as a training instrument has already been used in different domains. For example, VR training as vocational training is used in cases where the real situation may not be employed for practice due to the lack of access because it is highly dangerous or very costly [18]. Besides the safe environment, VR-based training offers an interactive learning experience for workers compared to conventional training methods that rely on audio, text, or images [55]. Furthermore, VR-based training is advantageous over traditional in-person training as it only requires a one-time development effort, making it cost-effective while ensuring consistency, applicability, and efficiency in workforce training. Lecture-based training sessions need the presence of a trainer and appropriate equipment to provide hands-on experience to trainees, while VR does not [2].

FIGURE 1.1: VR at the Dutch Police Academy [52]

Besides the physical advantages of using VR, there are a variety of other motivations for educators to use virtual reality. Research has shown that using VR can increase (intrinsic) motivation and enjoyment of students [31, 8]. The novelty of VR and the fact that students get the chance to interact with

interesting software and activities can motivate students better than traditional methods [20]. And an increased enjoyment is the result of utilising gamification or game-based learning in the VR modules [31]. When students are motivated, they tend to learn better [67].

Besides motivation, research has shown that using VR training can enhance student's self-efficacy. Self-efficacy refers to the students' beliefs and attitudes toward their capabilities to achieve success, as well as belief in their ability to fulfill tasks and the successful learning of the materials [5]. For instance, VR-based training improved self-efficacy in robot operation for construction workers compared to traditional in-person training[2]. Other studies in the medical field suggest that VR materials significantly enhance trainees' self-efficacy (increased familiarity, increased confidence, and reduced anxiety) and their satisfaction with the training while motivating them to use acquired knowledge and skills in clinical practice [10].

Even though there are many motivations to use VR in educational contexts, there are still problems with using the new technology in educational contexts. Problems include for example the training costs of teachers and students, and the VR module having insufficient realism or usability [31]. Regarding the usefulness: The goal of using VR as an educational tool is to provide an effective learning experience. However, this is not always achieved due to a lack of engagement with students and the ineffectiveness of implementing the VR module. Lack of student engagement with the designed system can lead to a form of boredom expressed by students [25, 26, 31].

The sole reason for the lack of engagement can be hard to pinpoint. While using VR in education may seem exciting, educators need to be careful not to rely solely on it to keep students interested. Even within the VR experience, if the educational design is not well-planned, students may still lose interest and not engage effectively [31, 3, 4, 27]. Besides the lack of engagement, it was also reported based on user evaluations that the implementations of VR were simply ineffective although the reason varied per paper. The variation in how users perceive the effectiveness of these systems suggests that individuals may have diverse reactions to VR educational systems [31]. Based on these findings it can be argued that it is not easy to just implement VR within the curriculum and that educators and VR designers have to be careful about how VR can be implemented in the best way so that the VR module can provide an effective learning experience for the students.

Debriefing is an important aspect of adult learning for simulations. Debriefing is defined as a facilitated phase which triggers reflective thinking after a simulation [12, 36]. Debriefing happens after a simulation and lets students reflect on their (virtual) learning experience. Usually, debriefing is led by an instructor, that triggers reflective thinking [12, 36], but it can also be done by the student individually or with a peer [13]. In simulation-based training, debriefing is indispensable to learning; students get the chance to examine their decision, and the consequences and can consider alternative courses of action [36]. For instance, debriefing increases performance score improvements during nursing simulation and research argues that debriefing experience should be emphasised in a standardised simulation learning experience [63].

1.1 Problem statement

VRange is a virtual reality module where PA students can learn about the National Firearm Safety Protocol (NFSP), practice shooting at a shooting range, and practice the shooting test, which is mandatory for all PA students. Learning how to handle a weapon with care is of utmost importance to every police officer. VRange is already available for students to practice with individually and for teachers to use in their lessons, however, it is not a mandatory tool to use. Nevertheless, not all students as well as teachers use VR. It may be not clear enough how the students can use VRange in their learning process and how VRange can enhance their learning performance. It seems that VRange lacks a form of guidance when used by the students and therefore may lack to convince the usefulness to the user.

Despite the benefits of debriefing after simulations, there is currently no form of debriefing at all after the VR simulation, where the students can reflect on what is learned in the virtual reality environment. This research will investigate whether implementing a form of debriefing after the VR simulation has a positive effect on the PA students' self-efficacy, learning motivation, and perceived usefulness regarding virtual reality training with VRange. Can debriefing improve the human-computer interaction between the student and the VR module, and increase the usefulness of the VR module? Will it provide a more effective learning experience and therefore be a better VR implementation?

1.2 Research goal and questions

Research goal: To discover if adding debriefing after a VR training module provides an effective learning experience in regards to knowledge, self-efficacy, intrinsic motivation, and perceived usefulness of the police academy students using VR.

Subquestions

RQ 1 What are the different forms of debriefing that can be used in VR firearm training for police academy students?

RQ 2 How is the (perceived) knowledge of students influenced by the addition of a debriefing after VR firearm training?

RQ3 How does the self-efficacy of police academy students change after completing the VR firearm training module with self-debriefing, group debriefing or without debriefing?

RQ 4 How does intrinsic motivation of police academy students differ after completing the VR firearm training module with self-debriefing, group debriefing or without debriefing?

RQ 5 How does the perceived usefulness of VR technology differ for police academy students after completing the VR firearm training module with self-debriefing, group debriefing or without debriefing?

RQ 6 What are the possible limitations and challenges of integrating debriefing in the VR firearm training module for police academy students?

1.3 Contribution of thesis

This research explores how Virtual Reality (VR) can be enhanced for adult education by incorporating debriefing sessions. The thesis aims to understand the significance of debriefing as a complementary tool to VR educational modules and its positive impact on students' self-efficacy, intrinsic motivation, and perceived usefulness. By integrating debriefing sessions, this study uncovers the potential benefits and offers valuable insights for educators and instructional designers seeking to seamlessly integrate VR into existing curricula. It helps bridge the gap between traditional teaching methods and educational technology.

Drawing from various disciplines, such as educational psychology, instructional design, and VR, the research provides interdisciplinary insights that contribute to a comprehensive understanding of integrating VR into educational settings. Furthermore, the findings from the experiment provide evidence-based recommendations for educators and VR developers on how to optimise VR learning experiences through the addition of debriefing sessions. This research also explores how learning engagement can be enhanced when debriefing is used after VR experiences.

In conclusion, this thesis emphasises the importance of debriefing to improve VR in education, offering exciting possibilities to enhance the learning process and create more effective and enjoyable educational experiences. The research thus not only contributes to Police education but also to the broader field of VR education

1.4 Outline of thesis

First, chapter 2, related work, will highlight what VR training entails and thereafter the advantages of VR training are introduced. The next subsection introduces debriefing, and the different types and presents a debriefing framework that will be used in the experiment. The chapter concludes with a description of the Firearm curriculum of the PA and introduces the VR module, VRange, which was developed for these lessons. In the method chapter 3 the design of the experiment is explained and the procedure is presented. The chapter ends with the data analysis strategy and the presentation of the hypotheses. Thereafter, the quantitative and qualitative results are presented in chapter 4 and discussed in chapter 5. Finally, the conclusion chapter 6 summarises the thesis, and its findings and presents the limitations and future research areas.

FIGURE 1.2: Two PA students wearing a VR HMD [52]

Chapter 2

Related work

2.1 Training in Virtual Reality

Immersive technologies are electronic, digital environments where data are represented and projected [47]. Immersive technologies are also known as extended reality; a broad term that includes virtual reality (VR), augmented reality (AR), and mixed reality (MR) [45]. Humans observe and interact with a (fully or partially) digital environment constructed by these technologies [47]. With AR, the user sees a real-time direct or indirect view of a physical real-world environment that has been enhanced/augmented by adding virtual computer-generated information to it [9]. Mixed reality (MR) is the fusion of real-world and computer-generated elements, blending what is real with what is possible. It combines the physical world with virtual constructs, allowing us to experience new objects and scenarios that don't exist in reality. An example is adding virtual objects or characters to a live video stream [17]. In VR the users are completely immersed because it is an alternate, completely separate, digitally created, artificial environment where the users navigate. The users are transported into a different digital world and operate in similar ways just like in the physical world (figure 2.1) [47, 66].

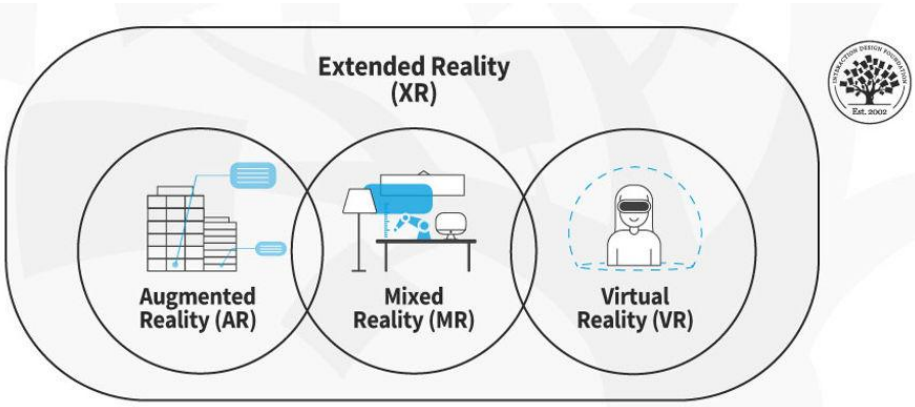


FIGURE 2.1: The relation between AR, MR and VR [68].

Current VR technology most commonly uses virtual reality headsets, also known as head-mounted displays (HMDs) [62]. VR has become much more affordable and available because of the recent growth of consumer-grade virtual reality devices. This supports the creation, application, evaluation, and delivery of interactive VR applications at a lower cost [71].

2.1.1 Defining VR training

Training is defined as 1) the act, process, or method of one that trains and 2) the skill, knowledge, or experience acquired by one that trains [43]. Some cases of training require the use of specific facilities to receive proper training for hands-on practice. VR technology makes it possible to provide real-world training through virtual environments while providing an effective and immersive training experience [71]. The simulations try to provide a realistic and believable experience that mirrors real-life situations, thereby offering learners more immersive and interactive learning opportunities compared to reading a textbook or manual [21, 54].

VR designed for training is used in different domains such as medicine, education, arts, entertainment, and the military [8, 46]. Training in VR could, depending on the domain, drastically reduce the costs of training in the long run, while increasing the number of training scenarios. VR training

scenarios are computer-generated and developers can create a variety of (personalised) scenarios [71]. For example, in the medical domain VR training has shown performance improvements for surgeons beyond traditional training approaches in a physical training environment [35]. Immersive training systems like VR modules can tap into gross and fine motor skill acquisition, maintenance, and expert-level performance [16, 46].

VR is used to create a fake environment for learners to improve their skills without having to worry about making mistakes and facing real-life consequences [62]. In workplace VR training, new employees can familiarise themselves with the workplace environment and operation through repeatable, mistake-tolerant VR training [71]. Such a mistake-tolerant environment can relieve stress that a new worker may have [39]. The employers can use the results of the VR training to evaluate whether their employees are ready to work in the field [71]. Sometimes training requires specific devices or equipment, such as military equipment, which can be dangerous to use. In a controlled virtual environment military recruits can practice their technical skills and improve their cognitive functions without being in danger if they make a mistake [73].

2.1.2 Police Firearm Training

Most law enforcement officers spend their on-duty time on non-threatening routine situations and rarely use their firearms. However, it is still important to prepare officers for the worst-case scenarios. In the rare situations where an officer is called upon to use force, learned skills and tactics become critical [7]. The ability of first responders to deal with critical events increases with the extent of received (intensive) training. Regular training and drills simulate different scenarios and help police officers improve their skills and develop the necessary reflexes. Poor marksmanship of police officers has led to officers missing their target when engaging an armed suspect and has led to bystander, or staff fatalities [15, 64, 30]. PAs therefore focus on firearms and defensive techniques during academy training.

VR firearm training's low-cost and rapid deployment characteristics are especially suitable for training police academy students on how to use their firearms. The traditional learning mode -*live firearm training on the shooting range* - is still the standard assessment method to complete the training and can never be replaced by VR [71]. Live-fire is a comprehensive assessment of the trainee's psychology, skills, and overall quality. To meet the qualified standards through the assessment, a police recruit needs to train hard and make full use of teaching resources to meet the set standards [62]. By implementing VR within the training assets the costs of training will be lowered, while the quality of training will rise [71]. As an example, the New York Police Department (NYPD) uses VR for active shooting training as part of their combat training. The training set-up can be highly customised to train first responders to deal with critical events effectively [40].

In conclusion, virtual reality (VR) provides immersive and realistic training experiences across various domains. It combines real-life scenarios with virtual environments, allowing learners to practice skills without real-world consequences. VR training is cost-effective, customisable, and enhances performance. In police firearm training, VR complements live-fire exercises by offering low-cost, deployable training solutions.

2.2 How VR training can benefit students

This section will go over how students benefit from using VR as a training tool. By giving examples of existing VR solutions.

2.2.1 VR training and self-efficacy

Learners' self-efficacy is concerned with one's perceptions of personal capabilities in task performance. It is the belief in one's capabilities to perform a specific task [5]. Humans draw from self-efficacy in order to complete tasks. Furthermore, perceived self-efficacy has an important presence in learning: having a high perceived self-efficacy about a certain task can lead to positive performance outcomes [24]. Self-efficacy is task-specific and is not conceptualised as a global personality characteristic; e.g., an individual may have a high self-efficacy at solving math problems but low self-efficacy at giving public speeches [29].

Self-efficacy can influence people in several important ways. Self-efficacy affects how individuals confront failure and manage challenges. An individual with high self-efficacy beliefs is more inclined

to invest more energy in a difficult situation, concentrate on solving problems, and continue their efforts for a longer period of time. A person with low efficacy is more likely to see a difficult situation as insurmountable, get frustrated, give up quicker, and be more emotionally focused [29].

Simulators and simulations can lead to effective learning and a higher self-efficacy of students through practical instruction [19, 28, 34]. High-fidelity simulators (simulators, where the reproduction of the situation is very faithful to the original [42]) lead to mastery learning (performance accomplishment), which produces higher performance outcomes [28, 34]. As an example, prior experience of flying in an aviation training simulator to provide basic instruction influenced the student pilots' self-esteem, self-efficacy, and performance positively [11].

However, in the following two examples, the self-efficacy did not necessarily improve after the simulation training. In the experiment by Sirakaya and Cakmak (2017), the effects of AR on student achievement and self-efficacy in vocational education and training were tested. Students from a Computer Hardware Course must gain both theoretical knowledge and applied skills to finish the course. Students need to learn how to work comfortably and in a self-confident way in the assembly process. Self-efficacy can play an important role in achieving the targets of the lesson as it affects individuals' behaviors. AR has a positive impact on student achievement in motherboard assembly, however, it has no impact on student self-efficacy related to theoretical knowledge and assembly skills. The researchers concluded that students already had high levels of theoretical knowledge and assembly skills before the implementation and therefore the self-efficacy did not increase significantly [65].

In an experiment by Holbrook et al.(2014), participants were tested on self-efficacy before and after a shooting simulator. The self-efficacy of the participants was lower after the simulator. Before the simulator the participants identified themselves as self-efficacious in completing certain tasks, after the simulator they identified themselves as anxious, worried, or upset; the realism influenced participants' task performance by increasing their emotional arousal. The simulator's high fidelity resulted in anxiety among many participants which halted their performance [24]. Although the participants struggled during the simulation, the trainer would remind them that the simulator was a place to learn and practice to take risks. The participants noted that despite the difficulty of the tasks, they learned by observing and considered it a form of learning known as vicarious experience [24].

While the effectiveness of self-efficacy in simulator-based learning has not been proven to have an effect by some of the mentioned studies, there is still value in researching and exploring its potential benefits. Simulators and simulations have been shown to enhance practical instruction and provide learners with valuable experiences. High-fidelity simulators can lead to mastery learning, which results in higher performance outcomes. Moreover, prior experience in simulators can positively influence learners' self-esteem, self-efficacy, and performance. However, the realism of the simulator may also result in anxiety among learners, which can impact their self-efficacy and performance. Yet, this strongly depends on the task and the simulation itself. Simulators remain a valuable tool for learning and can offer opportunities for both performance accomplishments and vicarious experiences. Therefore, it is important to better understand the impact of self-efficacy in simulator-based learning and to identify strategies that can help learners to maximise their potential. Finally, the aforementioned examples focus on simulation in the broadest sense, and not on VR specifically.

2.2.2 The relationship between motivation and VR training

VR learning environments increase motivation, liking, and engagement of students compared to conventional learning settings, e.g., classroom settings [38]. In this research, motivation is defined as the desire, or incentive held by a student to participate in a learning activity [31]. Research has shown that the novelty of VR is a factor that can improve student motivation [31]. Students are often excited to try something new, instead of working with traditional educational materials like text. In a study by Sattar et al., (2019), virtual reality was used for teaching and training 4th year medical students. Using VR as a learning methodology improved learning motivation and learning competency compared to video and text-based learning [56].

In another study, students receiving lab safety training in VR environments tended to give higher ratings of enjoyment and showed more positive pretest-to-posttest changes in intrinsic motivations compared with students who learned with the safety manual. Moreover, the students in the VR group showed significantly more positive pretest-to-posttest changes in self-efficacy than the text conditions [38]. It is important to have motivated students because better-motivated students have a tendency to learn better [67]. Last, the continual use of interactive VR can both improve student motivation and

retention [8].

However, it is important to take into account that educators can not solely rely on the novelty of VR to keep students motivated and interested [31, 3, 4, 27]. Therefore, the implementation of VR within the curriculum should be carefully taken into account and analysed to make sure that the user motivation and learning experience stays high.

2.3 Debriefing

Debriefing is defined as a post-hoc analysis of a series of events and situations, performed individually or in groups that involve observation, feedback, discussion, and reflection. It is a facilitated phase in which learners meet the actions and the context of their experience and analyse them [13, 12, 36]. Debriefing guides learners to recall, evaluate, and conceptualise their actions and decisions in real or simulated situations, thereby promoting reflection and meaning-making [37]. With the help of debriefing, students can reflect on the virtual learning experience they had in a simulator. In simulation-based training, debriefing is indispensable to learning; it provides the learners with the opportunity to examine their decision-making process during the scenario, their consequences, and consider alternative courses of action [36]. Different debriefing approaches demonstrated some benefit in terms of improvement in knowledge, self-confidence, self-efficacy and, (technical/non-technical) skills. Furthermore, one study demonstrated a reduction in learner anxiety after the use of a simulation with debriefing [36].

Guidelines for debriefing after simulations already exist within nursing education where debriefing plays a large part in the learning process of students. However, these guidelines are often based on virtual online simulations, and not on VR simulations, where the student is fully immersed into the simulation. In another domain, the educational gaming domain, most debriefing activities are omitted. However, without debriefing sessions, the effect of the educational game may be diminished, as some learners will see the activity as a stand-alone game and not connect it to a learning activity [48]. Earlier research has shown that participants who underwent debriefing demonstrated notable score improvements in their performance in comparison to those who did not receive debriefing [58, 63].

2.3.1 Difference between feedback and debriefing

Debriefing and feedback are two terms, sometimes used to describe the same thing. However in this research feedback is defined as the transmission of evaluative or corrective information about an action, event, or process to the original or controlling source [41]. Usually, feedback is given directly after the user makes a mistake whereas debriefing is used after the simulation has been completely finished. Feedback is the information about performance during the simulation, whereas debriefing is a facilitated reflective conversation [12]. As an example, in a VR solution, feedback would be an error message appearing on the screen once the player has dropped something, whereas debriefing takes place after the whole module is finished where the player can reflect on the made choices.

2.3.2 Debriefing types

Degand et al., (2021) identified 4 main types of debriefing depicted in figure 2.2. On the y-axis instructor-led debriefing and peer-led debriefing are compared. On the x-axis self-debriefing and group debriefing are compared. Instructor-led debriefing always includes an instructor, who can perform a debriefing with an individual (a student has their own debriefing session) or in groups (multiple students are debriefed at the same time). Well-trained instructors can help the learner to have a better learning and skill gain [13]. Novice learners may not have the knowledge and the experience to self-debrief and would benefit from a debriefing led by an instructor [36]. Peer-led debriefing is handled by the learners themselves and can be performed individually or in discussion groups [13]. Group debriefing is performed simultaneously with multiple learners and can improve the communicative skills of the learners. Last, self-debriefing is an individually performed debriefing, usually based on a series of questions or a summary of the learners' performance after the simulation or as a written debriefing or video-evaluation of the simulation [13].

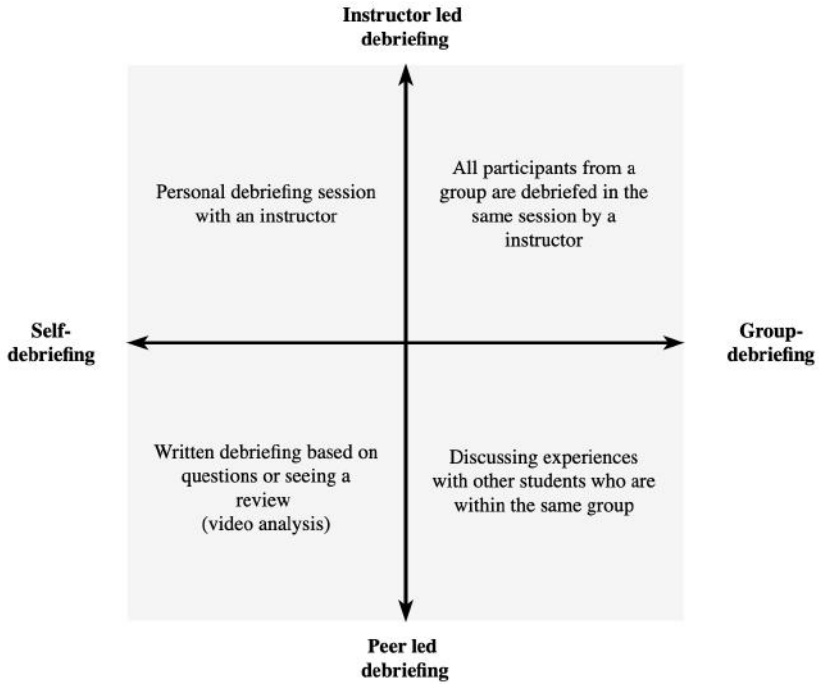


FIGURE 2.2: Debriefing types visualised [13]

2.3.3 Debriefing and VR training

As mentioned before, within the nursing education domain, simulations and debriefing have been researched the most. However, still, some unexplored research opportunities exist. A review on self-debriefing after virtual simulation in nursing schools found that virtual simulation's unique features have the potential to improve understanding and enhance learning outcomes through self-debriefing. Further investigation in this area could establish a body of evidence that informs best practices for self-debriefing and transform debriefing practices in the virtual world [33]. Degand et al., (2021) proposed an immersive post-event debriefing tool that features a replay of the simulation. With these solutions, learners will experience a better reflection and observation of their performance. The learner will be debriefed in VR where they can move freely in the scene during the replay. The learner can thus see their own actions, from a third person perspective [13]. Conducting a debriefing after a virtual reality simulation can improve learners' engagement and help them to remember their performance more easily, which will facilitate the reflection process [13].

Besides, debriefing helps to address misunderstandings or mistakes that happen during an educational game. After having addressed these misunderstandings, it boosts learners' confidence in their ability to achieve the specific goal. When learners believe in their capability to achieve specific objectives, their confidence increases, which can be maintained [6]. If learners lack confidence in their ability to accomplish a task, they may avoid it, and they won't be motivated to act in ways they believe will result in negative outcomes [60].

Having a debriefing session after a VR module can play a crucial role in influencing students' perceived usefulness of the VR technology. The Technology Acceptance Model (TAM) suggests that perceived usefulness is a key determinant of users' acceptance and adoption of new technologies [57]. As argued before, through debriefing after VR training students can gain a deeper understanding of the subject matter through reflection. Because of the reflection on their performance, students are more engaged in the learning experience making the learning experience more valuable. The TAM suggests that users are more likely to accept and adopt a technology when they perceive it as valuable and advantageous [57], which we hope to increase through debriefing.

2.3.4 Debriefing at the Dutch police academy

Whereas debriefing is a facilitated phase after an activity, briefing takes place before the activity. Debriefing and briefing are not anything out of the ordinary for police employees; they are a crucial part of the management and information process within the police organization. The (de)briefing strategy

is part of Information-driven police work, introduced in 2009, which aims to collect and analyse information and knowledge to make decisions based on overview, insight, and prospects about how to approach safety problems [22].

Right now, debriefing is a plenary "moment" with the whole team to close the shift. It has multiple purposes: The first purpose is to tap information, in order to make it clear what information is important for the next briefing. The second purpose is to share experiences. The debriefing offers the opportunity to reflect on, learn, and improve the experiences employees have during their service. Finally, the debriefing also has a symbolic function in the context of team spirit because the service is concluded together. It is a moment where an operational manager can give attention to these employees, who have done their best to make it 'outside' safer [32].

There is no national prescriptive policy that helps or obliges the different police regions in detail to design the process of the (de)briefing in a certain (effective) way [59]. However, in 2014, the Intelligence research group of the Police Academy developed the briefing guide. This cardboard card contains tips for preparing and presenting a (de)briefing. Application leads to four effects of the (de)briefing:

1. Alertness: recognising situations on the street and being able to act accordingly;
2. Steering: giving direction to employees working on the street by means of assignments;
3. Team building: strengthening the bond between direct colleagues and other units;
4. Learning: improving performance by learning from each other.

The (de)briefing guide provides effective tips, for example, personalising who is going to do what (steering), and asking how colleagues would carry out assignments (to learn). On paper, debriefing works perfectly. However, in practice debriefing is not executed correctly and these tips are not always followed [22].

Quantitative research shows debriefings take place in two-thirds of the national police units. However, the need for a debriefing is low among police employees: about 54% of the employees of the units concerned indicate a need for a debriefing. Some of the employees who do not need a debriefing believe that a debriefing only has added value in the event of special events. Furthermore, many believe a debriefing after each shift takes too much time, is difficult to implement in practice and, according to some of the respondents, important information is shared anyway. The debriefing supporters emphasise the sharing of results and experiences, but also the conclusion of the service together and the team spirit as arguments for debriefing[32].

But why is the percentage of the need for debriefing so low? Some arguments include an information overload, the (de)briefing being executed by the wrong person, and the debriefing having the wrong content. What is noticeable is that not every team manager has the adequate (de)briefing skills to conduct a debriefing. In practice, the manager generally has to make do with his own practical experience and the skills are not always present [22]. It can therefore be a solution to practice individual debriefing and or group debriefing with peers early in the police academy education to make sure that police recruits can get familiar with how to effectively (de)brief.

Police research has shown that there are no clear guidelines on the way in which the debriefing should be structured, there is a lack of clarity about the question of what information should be included in the briefing, and in police practice there is hardly any plenary debriefing after the end of a shift. Researchers expect briefing and debriefing to remain a central theme within police research in the coming years [22].

2.3.5 Debriefing using The 3D Model of Debriefing

After having addressed all the benefits of debriefing, and where debriefing lacks in practice, it is important to establish what debriefing can look like after a VR simulation. For this research, the decision was made to focus on peer-led debriefing: The PA has limited instructor availability and because the PA has a vision for VR to be used by the students themselves without an instructor. Furthermore, using peer-led debriefing, students can practice the act of debriefing themselves, learn from it, and later use it in their police work. Because debriefing is very successful in the nursing domain, and because the peer-led nature of the debriefing had to be taken into account, The 3D Model of Debriefing by Zigmont (2011) has been selected as a framework [72]. Figure 2.3 depicts a visualisation of the model.

The 3D Model of Debriefing

The 3D Model of Debriefing consists of a framework for facilitators of debriefings. The model consists of three debriefing parts: Defusing, Discovering & Deepening.

In the defusing phase, the learner is allowed to release emotions and describe the experience. With the help of the defusing the student or facilitator can discover what issues are most important to the learner. The next step is discovering where the learner can identify and analyse the mental models guiding behaviours and then compare them with the new information they learned from the simulation. Learners in this phase should be encouraged to use analogical reasoning to apply mental models to novel situations.During the last phase, the deepening phase, the learner can learn how to apply the new information to the real environment [72].

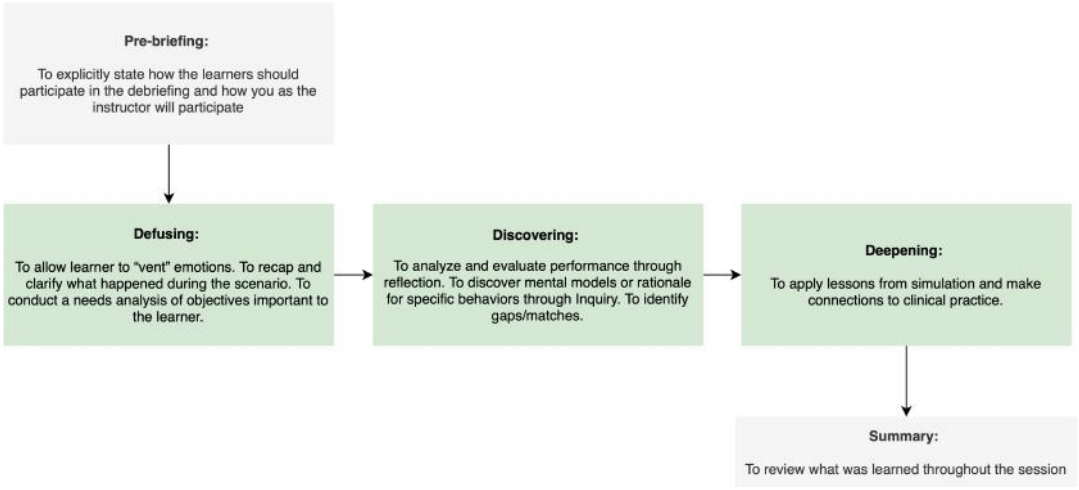


FIGURE 2.3: A visualisation of The 3D Model of Debriefing [72]

Before the debriefing itself, there is a pre-briefing of how the debriefing will take place and after the last step, deepening, there is a summary in which the learners can summarise what they learned throughout the session. In the experimental learning process, where these questions originate from, participation in key experiences and analysis of those experiences is important to gain knowledge because during debriefing students reflect upon the experience, identify the mental models that led to behaviours or cognitive processes, and students can build or enhance new mental models to be used in future experiences [72].

The 3D Model of Debriefing has some overlap with the Police's Briefing guide (2.3.4). Learning takes place during all phases of The 3D Model of Debriefing because the student can actively reflect and learn from the made decisions. Steering, giving the student directions, is apparent in the deepening phase where the student learns how to apply the new information into practice. Alertness is one consequence of the debriefing session because the student becomes more aware of their own decisions through the reflection on their actions. Teambuilding is only apparent if the debriefing is done in groups [22].

2.4 Firearm curriculum at the Dutch police academy

In the following section, the state of the art at the Dutch PA firearm curriculum is described. The current curriculum on firearm training is discussed. All information in this section is based on the studyguide "Vuurwapen Leerlijn PO21" [23]. The following information has been gathered:

The Firearm Educational Curriculum (FEC) (Dutch: Vuurwapen Leerlijn) is a mandatory and necessary component of the Police Academy Curriculum. To be allowed to carry the firearm, a student must be trained and assessed in accordance with the Police Violence Control Regulations (RTGP: Regeling Toetsing Geweldsbeheersing Politie). The FEC has a hybrid character: contact education, different educational materials, and working in learning groups alternate with each other. The student

is encouraged to take control of their learning process. The student will be assessed on “weapon treatment" (wapenhandelingen) and “firearm shooting skills" (schietvaardigheid pistool). Learning during the FEC is a continuous process that can be supported by different tools. The firearms training in which projectiles are fired is always supervised by a certified teacher of danger management/firearms teacher. Besides training with projectiles, other educational material is made available by the police academy for the students. Which educational material a student uses, depends on their needs and liking.

Students can train on elemental firearm handling at the police academy with VIPER laser shot or with Dryfire (instruction weapon). The VR training (VRange) can be followed at home or at the academy where students can start by learning how to work safely with a firearm. Students can also train by watching instruction videos to prepare for the training. The goal is to encourage students to try and experience all tools to discover which of these educational resources helps them most in their development.

2.5 VRange

VRange is a virtual reality tool that allows students to train independently of place and time (figure 2.4). This means that a student can train parts of the firearms learning line in any room (including at home). The VR tool has been developed in line with the modernisation of the police education [50].

FIGURE 2.4: Screenshot from VRange

2.5.1 Learning Goals of VRange

The following 4 learning objectives have been derived and implemented in VRange.

Explicit learning objectives are:

1. National firearms safety protocol (NFSP)
    - Once the participant has completed the training, they can explain in their own words what the national firearms and safety protocol is. In doing so, the participant names the measures to take prior to training.

2. Firearms operations
    - Once the participant has completed the training, they understands the manner in which they should handle the firearm.
3. New shooting test 2021 (RTGP; Regeling toetsing geweldsbeheersing politie)
    - When a participant has completed the training they are able to perform the components of the test shooting skills in the prescribed manner.

Implicit learning objective:

- Recognisable and distinctive components of the virtual shooting range.

Because of the time and resource limitations of this thesis project, only the first mandatory learning objective (National Firearms Safety Protocol) will be considered.

2.5.2 Didactic design principles of VRange

When a participant has practiced VRange they can act safely and protect their own as well as their peers' safety on the shooting range. The following didactic design elements have been processed in VRange[50]:

Learner agency and hybrid learning

The learner takes initiative, acts, and decides on his own learning process. The students are responsible for developing the knowledge, understanding, and skills required to handle firearms safely according to national safety protocols in their own time. Furthermore, the student can use VR any place, any time and therefore can combine the online components of virtual firearms education with firearms education on and around the shooting range [23].

Collaboration and coaching

To promote the transfer of learning, coaching is crucial. No matter how well "virtual firearms education" is designed, if it is not followed up on and around the shooting range and further along the learning line, it loses most of its effectiveness. During this learning line, fourteen (14) physical shooting lessons are offered, which can be combined with firearms education using VR as a learning tool.

Action-based education and knowledge sharing

During virtual firearms education, learning activities take place in authentic virtual situations and settings where learning is linked to reality on the shooting range. Much of the learning objectives are practically focused and described at the application level. Hands-on learning and practical experience increase participant motivation. Besides being motivating, authentic situations are also a preview of reality and the participant's performance on the shooting range. VRange allows the participant to actively learn in a safe and realistic environment.

2.5.3 Current usage of VRange

Students can start in the second quarter (Q2) of their first year with the VRange module. Firearms education is offered in quartiles three and four. Because the student can start with VR in Q2, the students have the opportunity to master the material before the contact education. They can get familiar with the material through orientation and presentation and thereafter can exercise in practice and evaluate and reflect on the shooting range itself [23].

At the moment, VRange has no real implementation guideline, other than that students can just borrow a VR device at the student desk. The learning didactics and goals make it clear that the VR tool has been designed with care. It is therefore important that the educational tool is implemented with care to make sure that what needs to be learned is learned.

As mentioned in the introduction, using new technology in an educational context may come with problems such as a lack of engagement with students and the ineffectiveness of implementing the VR module [25,26,31]. Although VR training initially sparks excitement due to its novelty, educators and designers cannot solely rely on this novelty to maintain student interest. If the educational design is not well-planned, students may lose interest and not engage effectively [31]. It is therefore important

to look into and experiment with different strategies that may improve the learning experience of students using VR training.

While VRange is currently available for individual student practice and for teachers to integrate the tool into their lessons, it remains an optional tool rather than a mandatory component. This results in not all students and teachers utilising VR in their learning and teaching processes. To address this, there needs to be greater clarity on how students can effectively use VRange to enhance their learning performance. The lack of guidance for students when using VRange may be a contributing factor to its perceived usefulness, as users may not fully understand its potential benefits (besides just having fun with VR). Thus, establishing guidelines and support for students using VRange could enhance its overall effectiveness and encourage usage among students and teachers.

2.6 Aim for the current study

Currently, VRange is used as a self-learning method with no form of debriefing. Literature has shown that debriefing has many learning benefits including the rise of self-efficacy and motivation of the students, which can enhance the overall performance of a student. However, debriefing in relation to self-efficacy and motivation has not been widely researched in connection with Virtual Reality simulations. Furthermore, VRange has no real implementation guidelines. It is important to look into ways to improve the engagement with students using VRange and ways to improve the effectiveness of VRange.

Therefore, this research will explore the effects of debriefing on self-efficacy, intrinsic motivation, and perceived usefulness of PA students after training in VR with VRange.

FIGURE 2.5: Teacher and student using VR at the Police Academy [52]

Chapter 3

Method

3.1 Study design

The purpose of the present study is to explore the effects of debriefing strategies after a VR module. The conducted research used quantitative data to measure self-efficacy, intrinsic motivation, perceived usefulness, and debriefing quality using existing scales. Furthermore, qualitative data has been gathered by asking some exploratory questions at the end of the post-questionnaire survey.

The self-debriefing (SD) was provided in a written assessment form. Participants received the reflective questions on paper and wrote their answers on the same paper. The peer-to-peer (P2P) debriefing involved a discussion between the two participants with exactly the same questions. After the debriefing, the participants filled in a post-debriefing questionnaire.

The following study is predominantly a between-subjects design; there are 3 groups of participants and the results of the groups are compared to each other. The three groups are the no-debriefing group (ND-group) which acts as the control group, the self-debriefing group (SD-group), and the peer-to-peer-group (P2P-group). However, there is also a within-subject design in this study because the pre- and post-questionnaire are compared to each other for each group.

3.2 Study Population

Participants were recruited from the Police Academy Amsterdam. Using cluster sampling, learning teams were selected from a pool of 15 PA learning teams that started their police education at the end of January 2023. It was necessary that the students had not been on the PA shooting range because all participants of all groups must have roughly the same amount of pre-knowledge. With this in mind, 6 of the 15 learning teams were selected based on their schedule. Each learning team consisted of 7 or 8 students. The VR training session was scheduled in the timetable of each team. The experiment had 3 conditions and for each condition 2 learning teams participated in the experiment. Each team was randomly assigned to a debriefing method.

3.2.1 Population demographics

A total of 46 students participated in the study. The ND-group consisted of 15 students with a mean age of 27 (6 females, 9 males), the SD-group (SD) consisted of 16 students with a mean age of 26 (7 females, 8 males, 1 other) and the P2P-group consisted of 15 students with a mean age of 23 (5 females, 10 males).

3.3 Materials

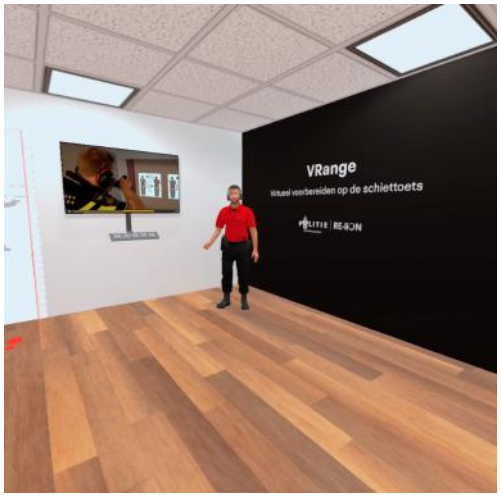
3.3.1 Meta Quest 2

The standard VR headset of the PA is the Meta Quest 2. The Meta Quest 2 is a VR headset released in 2020. Besides the headset, 2 third-generation Oculus Touch controllers are needed to use the VR headset (figure 3.1). The PA has on each location 16 enterprise variants of VR headsets for students and teachers to use. For this experiment, only 8 VR sets were needed per experiment.

FIGURE 3.1: VR glasses and controllers used by the Police Academy

3.3.2 VRange

The VRange training simulation (fig. 3.2) was used by every group in the experiment. As mentioned before in **chapter 2.5**, the VRange module was developed by the PA VR development team together with a third-party Relion. For this experiment, the first lesson about the national firearm safety protocol and the fourth lesson about shooting was chosen.



(A) VRange screenshot first scene

(B) Shooting Range in VRange

FIGURE 3.2: 2 screenshots depicting the two rooms in VRange

3.3.3 Debriefing questions

The debriefing questions for self and peer-to-peer debriefing were based on The 3D Model of Debriefing by Zigmont et al.(2013)[72]. These debriefing questions originated in health care education and the questions were designed for experimental learning (see 2.3.5). Furthermore, for this research the debriefing was designed to be executed without an instructor; the debriefing was peer-led, and the two forms of debriefing distinguished themselves by one being self-debriefing and the other debriefing being performed in groups of two (see 2.3.2).

For this research the following questions were given to the debriefing groups after the experiment:

- **Defusing**

1. Describe what you experienced in VRange.
2. How did it feel to be on the shooting range virtually?
3. Describe 2 or more things that went well during the simulation.
4. Describe 2 or more things that did not go well during the simulation.

- **Discovering**

  Choose 1 described situation that did not go well from point 4.

5. What went wrong?
6. Why did it go wrong?
7. Looking back, what was the train of thought that led to the mistake you made?

- **Deepening**

8. If you experienced the previously described situation on the real shooting range yourself, how would you act differently?
9. Can you think of other situations outside the shooting range where the mistake could be made, what the consequences are and how it could be avoided?

- **Summary**

  Today in VRange we learned virtually about the national firearm safety protocol and practiced shooting on the virtual shooting range.

10. Summarise in your own words what you learned in the simulation.
11. What is 1 thing you can take away from this Virtual Reality session that you can use while preparing for the lessons at the shooting range?

The self-debriefing group received the questions on paper with room to write their answers below the question whilst the peer-to-peer groups received the questions on a paper to discuss in pairs.

Other materials

Before the experiment, the participants got an explanation from the researcher about the experiment, how to use VR, how to navigate in VR, and how to start VRange. The whole explanation was printed on paper and used for the explanation. Furthermore, the questionnaires were made in Qualtrics XM, an online survey tool provided by Utrecht University [69]. Participants could access the pre- and post-questionnaire by scanning a printed QR code with their mobile device. The participants used their personal mobile devices to fill in the questionnaire.

3.4 Procedure of research

3.4.1 Preparing the experiment

The experiment took place at the Police Academy in Amsterdam on two separate days. The Dojo, where students usually get physical training, was used for this experiment. The Dojo had soft floors and walls which was quite advantageous for this experiment because if a student bumped into a wall it would not hurt. Because multiple students would execute the experiment at the same time it was important to make sure the VR equipment was ready to use. The VR consoles were evenly distributed into two rows, making sure that there was enough space to move in VR. A Guardian, a safety feature that lets you set up boundaries in the VR environment, was created for each headset in order to prevent two participants from clashing with each other. Once a participant moved too close to the edge of their play area, a red wall would appear, warning the participants that they needed to stay within their play area.

(A) 7 police academy students participating in the research

(B) Shooting stance of police academy student in VRange

FIGURE 3.3: 2 photo's depicting the procedure of the experiment

Once everything was set up the students entered the Dojo. They were asked to take off their shoes (it was not allowed to enter the Dojo with shoes), and to take off their Police duty belt. Thereafter the researcher introduced the research and experiment, and the students were asked to fill in the consent form if they wanted to partake in the experiment. The pre-questionnaire appeared after the consent form was filled in. The students received an explanation on how to use the VR equipment, how they could start VRange, and which lessons they needed to follow in VRange for the experiment. Furthermore, they received a paper sheet with all the information in case they missed something. Once everything was clear, and there were no further questions the experiment could begin. Students were asked to walk to a VR set, put on the device, and start VRange.

During the experiment, the researcher walked through the room to collect one controller from each participant, because only one controller needed to be used in VRange. Furthermore, students could raise their hands and ask questions to the researcher for troubleshooting.

3.4.2 Using VRange during the experiment

When the participants had the VR HMD on, the experiment could begin. The device was automatically turned on and the participant was transported into a lobby. In the lobby, the participants could navigate to the menu at the bottom and open the application library where they could click on VRange game at the top row. After the loading screen, the participants were in the front room (the room before entering the shooting range). Here the participants would meet Rem, the shooting instructor. Participants needed to follow the tutorial to learn how to navigate in VRange and to learn how the controller works. The tutorial consisted of an explanation with examples or tasks. After the tutorial participants needed to calibrate their height and could thereafter open the door to enter the shooting range.

Before selecting the lessons, the virtual teacher asked the students to put on the mandatory safety equipment; safety goggles, earplugs, and earmuffs. Once completed the lessons could be selected. For this experiment, students needed to complete the first lesson, about the national firearm safety protocol which consisted of the following seven parts:

1. Explanation of the National Firearm Safety Protocol
2. Walking discipline
3. Holster firearm and controlling the (virtual) weapon
4. Weapon inspection
5. Trigger finger discipline
6. Unloading procedure
7. Loading and reloading procedure

After this lesson was finished, participants could select the last lesson, high-score shooting, where they got the chance to shoot at the target on the shooting range from three different distances. Once completed, the lesson was over and students could teleport to the exit door to leave the simulation.

3.4.3 After the simulation

What participants needed to do after the simulation depended on the type of group they were assigned to. The ND-group had no debriefing; after the simulation, they were asked to directly fill in the post-questionnaire. The SD-group received a sheet of debriefing questions and a pen from the researcher and were asked to find a quiet spot in the Dojo to write down the answers to the questions individually. When completed they could fill in the post-questionnaire. The last group, P2P-group, needed to form pairs and receive the debriefing questions on a single sheet of paper. The pairs were randomly formed. The pairs were asked to find a quiet spot in the room to discuss the debriefing questions with each other. Once finished, the participants were asked to fill in the post-questionnaire. After all participants were done with the post-questionnaire, they were thanked by the researcher and could continue with their day.

3.5 Variables

To measure if the learning experience of working with a VR module changed with the addition of debriefing, the following variables have been sought out with care. A visualisation of the variables can be found in figure 3.4.

3.5.1 Measuring knowledge

To get an idea of what prior knowledge students already have on gun training, a prior knowledge scale was developed based on the national firearm safety protocol and the information provided by VRange. The questions were inspired by Markransky et al. (2018), where a seven-item scale assessed students' prior knowledge of laboratory safety [38]. Furthermore, the pre-knowledge test was also a way to see if the different groups differ in knowledge [44].

3.5.2 Measuring self-efficacy

Self-efficacy was measured before the VR experiment and again after the debriefing. A scale for measuring self-efficacy has been developed by Pintrich et al. (1991), with their Motivated Strategies for Learning Questionnaire (MSLQ), and has been adapted for this research [51]. There are nine questions about self-efficacy concerning judgments about the participants' ability to accomplish a task as well as their confidence in one's skills to perform that task.

3.5.3 Measuring intrinsic motivation

Intrinsic motivation inventory is a multidimensional measurement device intended to assess participants' subjective experience related to target activity in laboratory experiments [61]. The instrument assesses participants interest/enjoyment, perceived competence, and value or usefulness while performing a given activity.

3.5.4 Measuring perceived usefulness

The Technology Acceptance Model, or TAM, analyses the primary factors that affect a user's intention to use a technology: its perceived usefulness and perceived ease of use. The perceived usefulness is the extent to which a person believes a technology will enhance job performance, and perceived ease of use is the extent to which a person believes that using the technology will be effortless. For this research, only the perceived usefulness questions will be used [57] to discover if the addition of debriefing after the VRange module increased the perceived usefulness of the VRange.

3.5.5 Debriefing effectiveness scale

The Debriefing Experience Scale (DES), developed by Reed in 2012, was used to measure students' experiences following their assigned debrief [53]. This comprehensive 20-item scale includes four subscales, of which three were considered appropriate for this study: analysing thoughts and feelings, learning and making connections, and facilitator skill [70]. This scale has been applied in previous research concerning the debriefing of students after healthcare simulation sessions.

3.5.6 Qualitative measurements

Because of the exploratory research design of this experiment, some qualitative questions were included to discover the opinions of students on debriefing in general, after the VR-module and opinions on VR. Answering the questions was not mandatory.

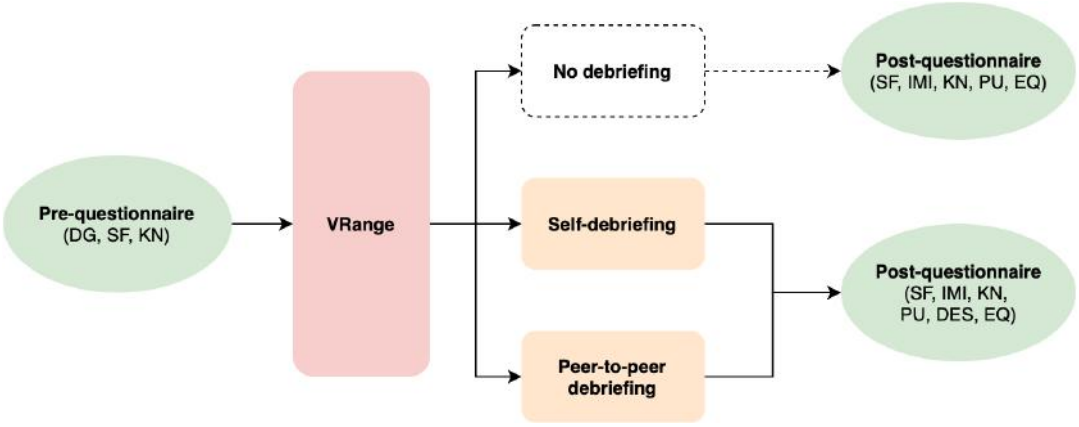


FIGURE 3.4: Variables of VRange visualised.

Demographics (DG), Knowledge test (KN), Self-efficacy (SF), Intrinsic Motivation (IMI), Perceived Usefulness (PU), Debriefing Effectiveness Scale (DES) & Evaluative Questions (EQ)

3.6 Data analysis method

A variety of types of data has been collected during the experiment. The following section describes how the different types of data were cleaned, and processed and what decisions were made while processing the data. Furthermore, the section explains how the cleaned data was analysed.

3.6.1 Data preparation

The data of the questionnaires was stored in QualtricsXM and was downloaded once all experiments were conducted. Three data files were gathered: one file for the pre-questionnaire and two for the post-questionnaire. There were two different post-questionnaires, one for the non-debriefing group and one for both debriefing groups because the DES-questions needed to be included in the questionnaire for the debriefing groups and because the open questions between the non-debriefing group and debriefing groups slightly differ.

Each participant had a participant number, and while comparing all the participant numbers of both groups it was discovered that two participants did fill in the pre-questionnaire but did not fill in the post-questionnaire. Thus the participants were removed from the data leaving 44 participants.

A different data file was made for each subscale in order to compare the results of the groups. For the self-efficacy scale and the knowledge questions, the pre-questionnaire and post-questionnaire needed to be compared to each other within subjects. The self-efficacy scale was a 7-point Likert scale, and one of the questions of the knowledge skill as well. The rest of the knowledge scale consisted of qualitative questions which were graded based on the answers in VRange. The 7 items from the knowledge scale are text-entry questions. The participants needed to answer this question in order to assess their knowledge of the NFSP. The answer to every question can be found in the NFSP and in the VRange module. The answers were written down and a coding scheme was created to determine if an answer was correct, insufficient, or incorrect, or for some questions just right or wrong. To visualise this data, the percentage for every question was determined for each subgroup, because the groups were not equal and could therefore not be correctly visualised using the raw data.

The post-questionnaire questions were all 7-point Likert scale questions. A couple of questions of the scale were inverted in the original scale to ensure the reliability of the questionnaire. For the data analysis these questions were inverted again, these questions are marked in the results section with an R. The qualitative questions were coded for each question. The NDEQ (no-debriefing evaluative question) question was coded into a yes/no answer, and the DEQ (debriefing evaluative question) (the

question was coded into a positive, neutral, or negative opinion. EQ1 was coded into more, less, or the same amount. EQ2 was coded into positive, neutral, or negative opinion, EQ3 was coded into yes or no, and EQ4 was not coded. Last, because the qualitative questions were voluntary to answer, not every question was answered by every participant, resulting in an uneven number of participants per group. To solve this for visualizing the data, the percentages for each answer per subgroup are calculated by dividing the number of answers by the total number of answers per question per subgroup.

3.6.2 Analysis strategy

The cleaned data was analysed using SPSS and RStudio. SPSS, as well as RStudio, were used to perform the statistical tests to compare the three groups with each other and to compare the individual pairs of groups. RStudio was also used to plot the data. In table 3.1 the research questions of this research can be found, together with the findings per question of the literature review and a data analysis strategy.

Analysing quantitative data

Different statistical tests are used to analyse the quantitative data. Likert scales were used to collect the quantitative data for this research, thus the collected data is ordinal. Because of the ordinal data the parametric tests, such as ANOVA, cannot be used because normality cannot be assumed [49]. Therefore, the following non-parametric tests will be used to analyse the data.

First, the Wilcoxon signed-rank test was used to compare pretest and posttest answers. For this test, two groups of data were needed from the same population. Second, the Kruskal-Wallis test was used to compare the answers of the three different groups at the same time for the post-questionnaire items. This non-parametric test was employed to test whether samples originated from the same distribution. After analysing the Likert data with the Kruskal-Wallis test, the Mann–Whitney U test (or Wilcoxon Rank Sum Test) was used for a post-hoc analysis to determine whether there was a significant difference between the subgroups. The Mann-Whitney U test is a non-parametric test used to compare two groups from different populations, such as the ND-group and the SD-group. [49]. The Kruskal-Wallis test and Mann-Whitney U test were used to compare all post-questionnaires.

Analysing qualitative data

The last questions of the post-questionnaire were open-text entry questions that explored the opinions of the participants on various topics regarding VR and debriefing. Per question, the data was coded (see 3.6.1) and visualised using bar plots to discover patterns. Besides visualising the data, the answers of the participants are used to explain the results of quantitative data.

Hypotheses

For the general research goal I hypothesise that adding some sort of debriefing, whether it was self-debriefing or peer-to-peer debriefing will elevate the total learning experience.

Sub-questions For the sub-questions, the following hypotheses have been formulated:

RQ 1 What are the different forms of debriefing that can be used in VR gun training for police academy students?

- See table 3.1

RQ2 How is the (perceived) knowledge of students influenced by the addition of a debriefing after VR firearm training?

- I hypothesise that there is a greater perceived knowledge after completing the VR firearm training with debriefing

RQ 3 How does the self-efficacy of police academy students change after completing the VR firearm training module with self-debriefing, group debriefing or without debriefing?

- I hypothesise that participants who would undergo debriefing will have a higher self-efficacy perception after the VR-simulation.

RQ 4 How does intrinsic motivation of police academy students differ after completing the VR firearm training module with self-debriefing, group debriefing or without debriefing?

- I hypothesise for motivation that the groups that have debriefing will have a higher learning motivation compared to the ND-group.

RQ 5 How does the perceived usefulness of VR technology differ for police academy students after completing the VR firearm training module with self-debriefing, group debriefing or without debriefing?

- I hypothesise that the perceived usefulness of the VR simulation will be higher for the debriefing groups compared to the ND-group.

RQ 6 What are the possible limitations and challenges of integrating debriefing in the VR firearm training module for police academy students?

- No hypothesis

TABLE 3.1: Research questions including literature review findings and data analysis strategy

Question	Literature findings	Data analysis strategy
RQ1: What are the different forms of debriefing that can be used in VR firearm training for police academy students?	Four types of debriefing have been identified. Besides the four types of debriefing, the 3D model [72], will be used to create debriefing questions for this research	Has been answered in literature study.
RQ2: How is the (perceived) knowledge of students influenced by the addition of a debriefing after VR firearm training?	Students undergoing debriefing can remember their performance more easily, and understand the experience better in hindsight	A knowledge test on firearm knowledge is conducted before and after the experiment. Perceived knowledge has a 7 point likert scale and is compare pre and post using the Mann-Whitney U test.
RQ3: How does the self-efficacy of police academy students change after completing the VR gun training module with self-debriefing, group debriefing or without debriefing?	Self-efficacy has been identified in the literature to improve after a form of debriefing, however, in practise self-efficacy does not always increase.	The pre- and post-questionnaire items on self-efficacy will be compared to each other to determine if for one group the self-efficacy improved the most using the Wilcoxon signed-rank test.
RQ4: How does intrinsic motivation of police academy students differ after completing the VR firearm training module with self-debriefing, group debriefing or without debriefing?	Intrinsic motivation of students is usually higher when using VR as an educational tool because of its novelty. Debriefing can also motivate students.	The post-questionnaire questions about IMI between the three groups are compared using the Kruskall-Wallis test, post-hoc analysis is done for each pair of groups using the Mann-Whitney U test.
RQ5: How does the perceived usefulness of VR differ for police academy students after completing the VR gun training module with self-debriefing, group debriefing or without debriefing?	Debriefing after VR modules may influence students' perceived usefulness of the technology, aligning with the Technology Acceptance Model (TAM). Reflection fosters deeper understanding and engagement, potentially increasing VR adoption.	The post-questionnaire questions about PU between the three groups are compared using the Kruskall-Wallis test, post-hoc analysis is done for each pair of groups using the Mann-Whitney U test.
RQ6: What are the possible limitations and challenges of integrating debriefing in the VR firearm training module for police academy students?	This question will be answered using the collected data	The answer for this RQ will be based on answers of the qualitative questions

Chapter 4

Results

The questions from the questionnaire can be found in appendix B.

4.1 Group demographics

The ND-group consists of 15 participants (6 female, 9 male). Of this group, 6 participants visited a shooting range before, and 5 participants shot a gun before. The SD-group consists of 15 participants (5 female, 9 male). In this group, 7 participants visited a shooting range before and 6 had shot a gun before. The P2P-group consists of 14 participants (7 female, 7 male, and 1 other). 6 participants of this group had visited a shooting range before, and 6 shot a gun before.

Of the participants of the ND-group, 6 participants have never experienced VR before, whilst 6 have had a brief encounter of 1 to 10 hours with VR before this experiment. The remainder of the 3 participants gave subsequently (10-20, 10-50, 50+ hours) more experience in VR. In SD-group 10 participants have no VR experience, while the other 5 participants have 1 to 10 hours of VR experience. In the P2P-group 10 participants had no VR experience, 2 participants had 1-10 hours of experience, 1 participant had 10-20 hours of experience and the last participant had over 50+ hours of experience.

4.2 Quantitative data

4.2.1 Comparing pre and post experiment results

Knowledge

The first item of the knowledge questions (K1) of the questionnaire assessed how much participants of each group knew of the protocol. The Wilcoxon signed-rank test is used to compare the pre-and post-questionnaire of the students of each group before and after the experiment. The participants of all groups reported that they knew more about the protocol after the VR simulation compared to before the experiment (table 4.1).

TABLE 4.1: Comparing perceived knowledge before and after the experiment

	Pre-mean	Pre-SD	Post-mean	Post-SD	Z	*p*
ND	1,67	0,900	4,20	1,821	-3,077	0,002
SD	2,27	1,163	4,20	1,207	-2,761	0,006
P2P	3,07	1,685	5,29	1,267	-2,647	0,008

This knowledge gain can be confirmed by the answers to the knowledge questions K3 to K8. These items are basic knowledge questions about the protocol. K3 and K4 asked participants if they were familiar with the two disciplines (walking and trigger) of the protocol. For items K3 and K4, the ND-group as well as the SD-group had more yes answers after the experiment. The P2P-group was already familiar with both disciplines before starting the experiment. Results can be found in table 4.2 and are visualised in figure 4.1 & 4.2.

The frequency of the text entry questions item K5 to K8 are displayed in table 4.3 and visualised in appendix C.

K5 asked participants if they knew at which moment the trigger finger was located on the trigger. The correct answer is when you are making the conscious decision to shoot at the target. There is an

TABLE 4.2: Answers of item K3 and K4 pre- and post-questionnaire per participant

		K3 pre	K3 post	K4 pre	K4 post
ND	Yes	8	14	9	14
	No	7	1	6	1
SD	Yes	7	13	10	15
	No	8	2	5	0
P2P	Yes	14	14	14	14
	No	0	0	0	0

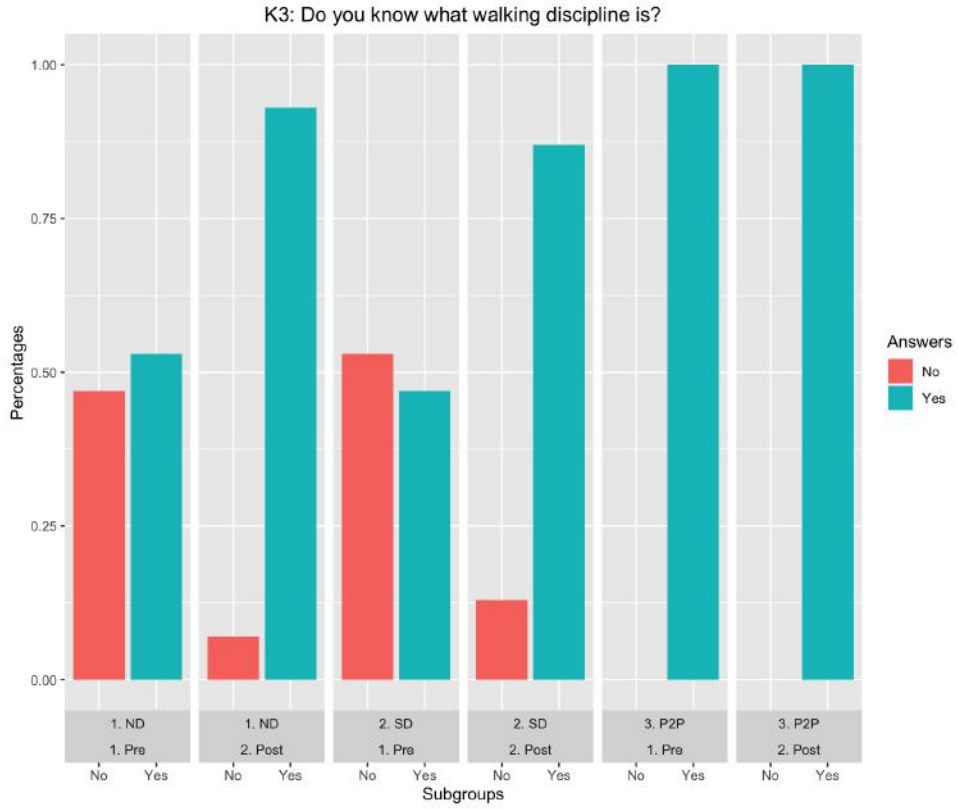


FIGURE 4.1: Barplot of K3

improvement for the ND-group and the P2P-group in the number of correct answers to this question. The SD-group stayed roughly the same (figure C.1). K6 asked the participants what kind of safety protection is compulsory to wear at the shooting range. The correct answer consists of three fold: when entering the shooting range the student must wear eye protection, earplugs, and earmuffs. If a student has all three answers, the answer is considered correct. Two answers containing eye and ear protection are considered insufficient. Less than two correct items are considered to be incorrect. Comparing the results of the subgroups it is noticeable that every post-condition has more correct answers than the pre-condition (figure C.2).

Item K7 asked participants what a safe direction is to aim the weapon. The correct answer to this question is up, down, or at the bullet trap. Most participants of all subgroups answered this question correctly in both conditions (figure C.3). The last item, K8, asked participants in what ways it is possible to check the condition of the weapon. The condition of the weapon is loaded or unloaded. Most of the participants of all subgroups have this question incorrect in the pre-condition. However, in the post-condition, the number of correct answers is a lot higher (figure C.4).

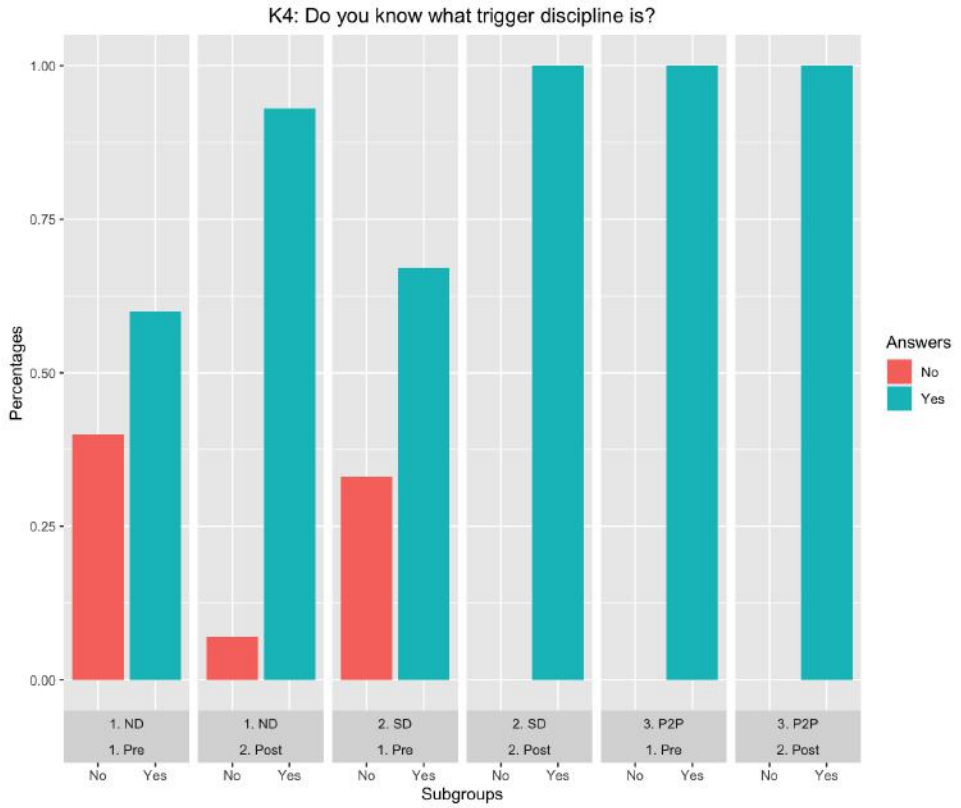


FIGURE 4.2: Barplot of K4

TABLE 4.3: Item K5 to K8 pre- and post-questionnaire

		K5 pre	K5 post	K6 pre	K6 post	K7 pre	K7 post	K8 pre	K8 post
ND	Correct	7	13	4	7	12	13	6	13
	Insufficient	5	0	9	8	1	1	1	0
	Incorrect	3	1	2	0	2	1	8	2
SD	Correct	13	13	0	9	10	13	8	12
	Insufficient	0	1	11	6	4	0	0	0
	Incorrect	2	1	4	0	1	2	7	3
P2P	Correct	9	13	0	8	11	11	8	12
	Insufficient	4	0	12	6	1	1	0	0
	Incorrect	1	1	2	0	2	2	6	2

Self-efficacy

The self-efficacy questions included in the pre-and post-questionnaire are also analysed using the Wilcoxon Signed rank test. Participants were asked to answer these statements on a 7-point Likert scale ranging from completely disagree to completely agree.

All groups have a significant pre- to post-questionnaire difference for SE1 (*I am confident that I understand the full NFSP*) and SE2 *(I am confident that I understand the more complex concepts related to the protocol)* (see table 4.4 for the Z-values and p-values of the different groups). For question SE3, which asks the participants if they believe they will receive an excellent grade for the shooting education, the ND-group as well as the P2P-group have a significant result. Furthermore, only the ND-group has a significant result for question SE4: *(I am certain I can understand the most difficult materials presented in the readings for this course)*.

The ND-group had the most significant results with 4 out of the 9 questions being significantly different, followed by the P2P group with 3 out of the 9 questions and the SD-group with 2 out of the 9 questions.

Question 5 up to including question 9 has no significant results when comparing the pre- and post-results of the groups.

The following questions were answered by the participants:

SE5 I am confident I can understand the basic concepts taught in this course.

SE6 I am confident I can understand the most complex material presented by the instructor in this course.

SE7 I am confident I can do an excellent job on the assignments and tests in this course.

SE8 I am certain I can master the skills being taught in this class

SE9 Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this course

TABLE 4.4: Comparing pre- and post self-efficacy

		SE1	SE2	SE3	SE4	SE5	SE6	SE7	SE8	SE9
ND	Z	-2.615	-2.890	-2.062	-1.980	-0.632	-1.667	-0.586	-0.707	-1.134b
	p	**0.009**	**0.004**	**0.039**	**0.048**	0.527	0.096	0.558	0.480	0.257
SD	Z	-2.444	-2.517	-0.182	-1.725	-0.302	-0.351	-0.618	-1.633	-1.897b
	p	**0.015**	**0.012**	0.856	0.085	0.763	0.726	0.537	0.102	0.058
P2P	Z	-2.059	-2.684	-2.620	-0.816	-1.897	-0.361	-1.344	-0.782	-1.008b
	p	**0.040**	**0.007**	**0.009**	0.414	0.058	0.718	0.179	0.434	0.313

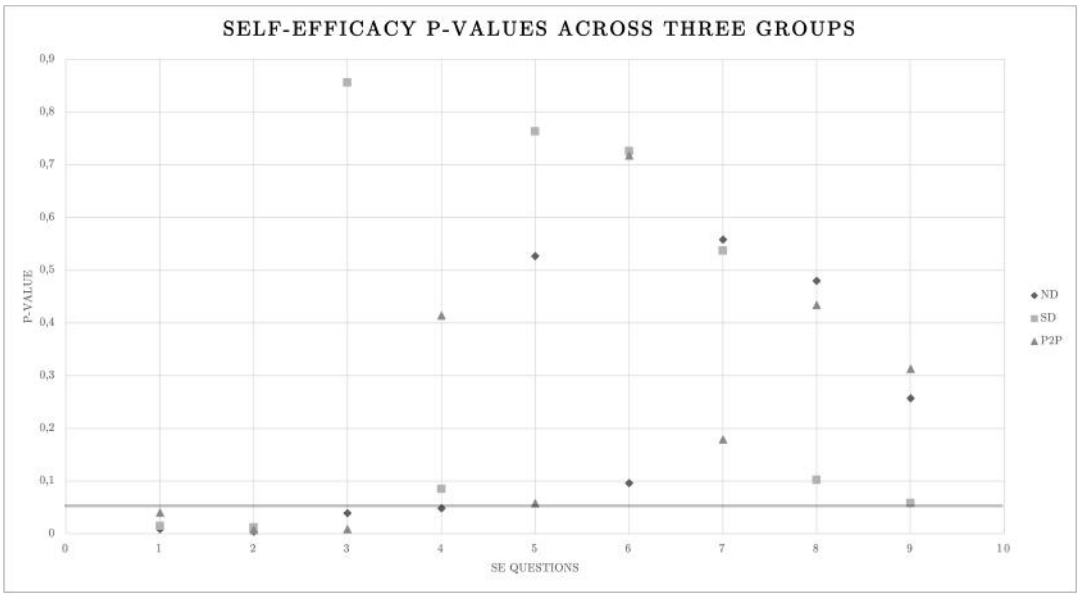


FIGURE 4.3: Self-efficacy per question

4.2.2 Post-questionnaire questions

Motivation

The Kruskall-Wallis test was used to determine if there is a difference between the three groups for each motivation question. No significant results have been found between for each question, the lowest p-values are found for items IMI1 (H(2)=3.8357, p=0.1469), which asked if VRange was fun to do, and IMI7 (H(2)=4.3041, p=0.1162), which asked if it was important for the participants if they were during well in VRange. Post-hoc Mann-Whitney U tests were used to compare all pairs of groups. No significant results have been found between the ND-group and the SD-group as well as between the SD-group and the P2P-group. Between the ND-group and the P2P-group a Mann-Whitney U test indicated that the item IMI7 is greater for the P2P-group (Mdn= 5.13) than for the ND-group (Mdn = 5.7), U=59.5, p=0.03934 (figure 4.4).

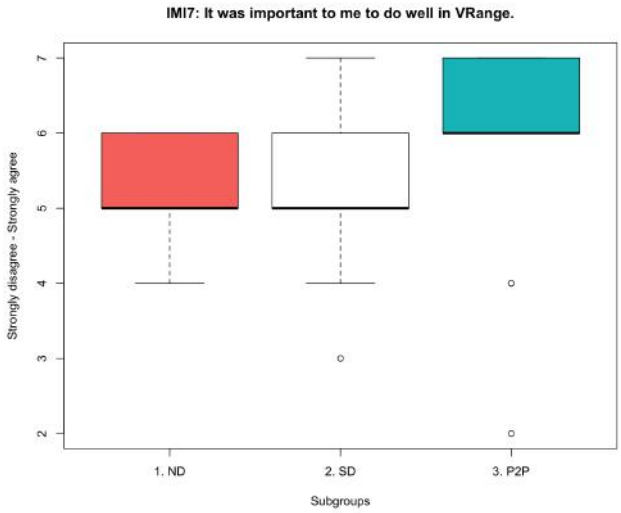


FIGURE 4.4: Boxplot of IMI7 comparing the ND-group and the P2P-group

Perceived usefulness

Like motivation, the perceived usefulness items have been analysed among the three groups using the Kruskall-Wallis test. No significant results have been found. Post-hoc analysis with Mann-Whitney U test revealed that there is a significant result for item TAM2 (Using VRange would improve my shooting performance) when comparing the ND-group (Mdn = 4) with the SD-group (Mdn=5), U=59.5, p=0.02623 (figure 4.5). No other items have a significant result.

Debriefing

The debriefing items were only applicable to the debriefed groups. A Mann-Whitney U test has been conducted for the 13 items of the questionnaire. Three items have a significant result; items DES8, DES11, and DES12. DES8 asked participants if believed debriefing helped them to become more aware of their role as police officers (figure 4.6. DES11 asked if the participants thought there was sufficient guidance during the debrief (figure 4.7). DES12 asked if the debriefing gave the participants a way to reflect on their actions during the simulation (figure 4.8). A Mann-Whitney U test has been conducted to compare the distributions of the DES8 item between the SD-group and the P2P-group, revealing a significant difference (U = 57.5, p = 0.03394), with the SD-group reporting a higher mean rank. Furthermore, for item DES11, the test reports a significant difference (U=55.5, p = 0.02717), again in favor of the SD-group. Last, a comparison of item DES12 indicates a significant difference between the SD-group and P2P-group (U = 62, p = 0.04999).

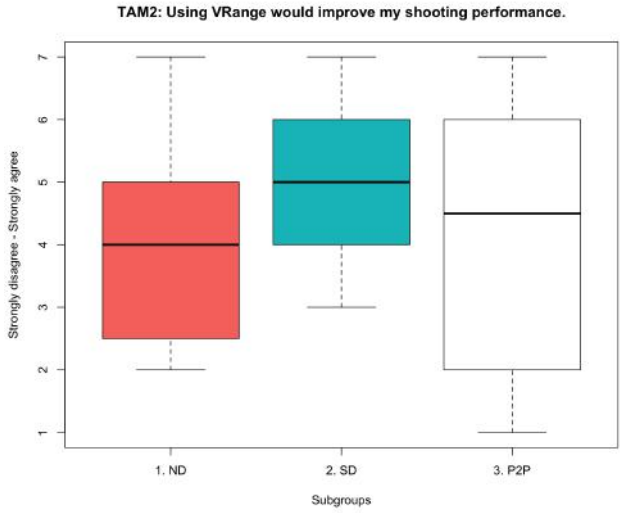


FIGURE 4.5: Boxplot of TAM2 comparing the ND-group and the SD-group

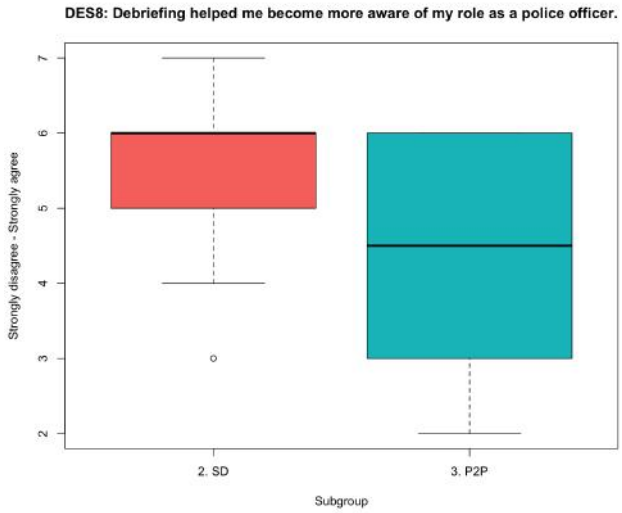


FIGURE 4.6: Boxplot of DES8 comparing the SD-group and the P2P-group

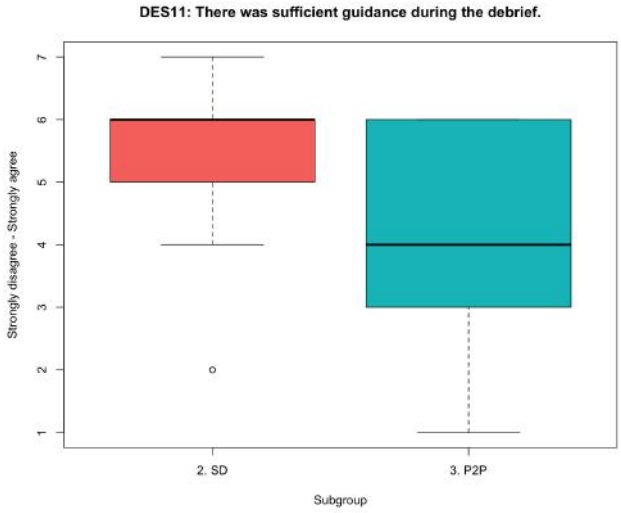


FIGURE 4.7: Boxplot of DES11 comparing the SD-group and the P2P-group

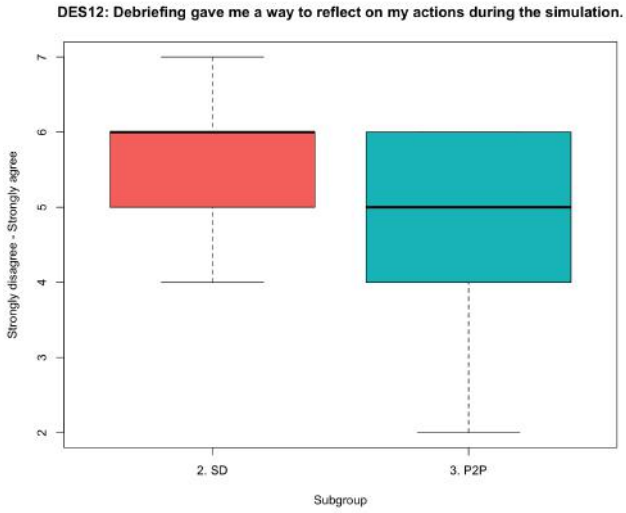


FIGURE 4.8: Boxplot of DES12 comparing the SD-group and the P2P-group

4.3 Qualitative Results

Besides the quantitative results, some qualitative results have been gathered. In table 4.5 the questions have been listed down. The NDEQ question (No Debriefing Evaluative Question) was only answered by the ND-group whilst the DEQ questions (Debriefing Evaluative Question) were asked to the two debriefed groups. The other questions are answered by all the groups respectively. The questions were completely voluntary, resulting in some questions having more answers than other questions. This is all mentioned in detail below.

4.3.1 Sentiment on debriefing of the ND-group

TThe first question (NDEQ) explores the opinions of the ND-group on debriefing. Out of the 15 answers, 8 participants did not think they needed a debriefing moment after the simulation, 6 participants would like to have a debriefing moment, and 1 participant is neutral (figure 4.9. The disagreeing participants mention that the VRange simulation is very "straight to the point" and therefore a debriefing moment is not needed. The participants who want a debriefing argue everyone has a different experience in VR, and students can learn from each other's experience.

TABLE 4.5: Exploratory questions per group

Code	Question	ND	SD	P2P
NDEQ	Do you think you would have needed a debriefing moment after the simulation? Why/why not?	X		
DEQ	What did you think of the debriefing questions? What did you like and what could be improved?		X	X
EQ1	Do you think you would learn more, less or the same amount without debriefing? Why?	X (R)	X	X
EQ2	What is your opinion about a debriefing in general after a Virtual Reality simulation?	X	X	X
EQ3	If you used VR more often at the police academy, would you like to save your debrief answers? Why or why not?	X	X	X
EQ4	Do you want to say anything else about the experiment, VRange or the debriefing?	X	X	X

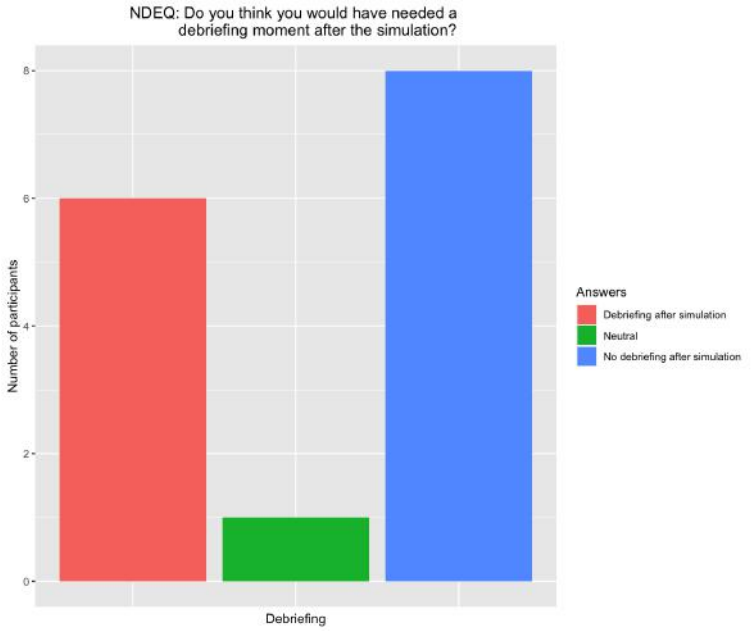


FIGURE 4.9: NDEQ

4.3.2 Opinion on the quality of the debriefing questions

The DEQ item was answered by the two debriefed groups. The question explores the quality of the debriefing. Out of the 15 participants in the SD-group, 11 answered the question: 9 participants provided positive responses, and 2 were neutral. The positive answers mention that the questions are clear and great. For example, one participant wrote, "(The Questions were) good because it makes me think about my actions." Among the participants with neutral answers, one mentioned that there were too many questions, but the content was good. The other neutral participant mentioned that they missed the question about how the experience can be enhanced.

Of the P2P-group 12 of the 14 participants answered the question, with 10 participants having a positive answer and 2 participants negative. One of the participants with a positive answer points out, *"Good that it (the debriefing) had to be done together because you can learn from others."* Another participant appreciates the questions, stating that they are good, not too deep, but still substantive. Additionally, another participant notes, *"They (the questions) help; this made you think about what you experienced in VRange."* However, two participants are more critical. One reports, *"In my view, the content of the lesson is not relevant to practice. This makes it difficult to cover all the questions in detail."* The other participant remarks, "Quality of sharpness (of the questions) could/may be better."

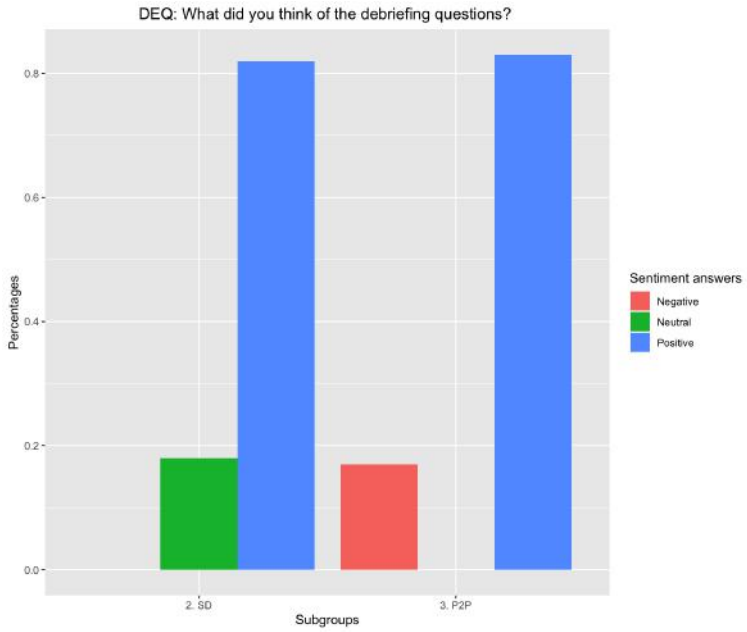


FIGURE 4.10: DEQ

4.3.3 Questions for all groups

Perceived knowledge gain of the participants

The following items were asked to participants of all groups. Item EQ1 asked whether the participants thought they would learn more, less, or the same amount without debriefing. For the ND-group, the question was reversed. Of the ND-group participants, 14 out of 15 participants answered the question, with 8 participants stating learning more with debriefing and 6 participants mentioning learning the same amount. The participants who thought they would learn more with debriefing argue that you can learn more because everyone's experience is different and it may be useful to hear what feedback other students got in the simulation. The other 6 participants who answered the question think they would learn an equal amount with debriefing. *As one put it: "(You learn) Just as much (and it) is nice to see what everyone thought of it (VRange)."*

In the SD-group (12/14 participants) 9 participants mention learning less without debriefing, and 3 learning the same amount. The participants who mention learning less without debriefing explain that without debriefing they would not evaluate (the experience) and thus reflect less on the study material. Furthermore, debriefing can clarify the students' views on the material. The 1 out of the 3 participants that argued learning an equal amount mention the following: *"For me, a debriefing doesn't necessarily help me to think extra about my actions and achievements. I process things quite quickly so I had already done that before debriefing".*

Of the 7 participants P2P-group who answered the question, 4 answered learning less without debriefing and 3 pointed out that they would learn the same amount. Like the other groups, the participants mention that debriefing can clarify the simulation, that it can help with looking critically at your actions in the simulation and you can do this together with your peers. Of the ones mentioning learning the same amount one participant argued that they saw the simulation more as a game and therefore would not need a debriefing.

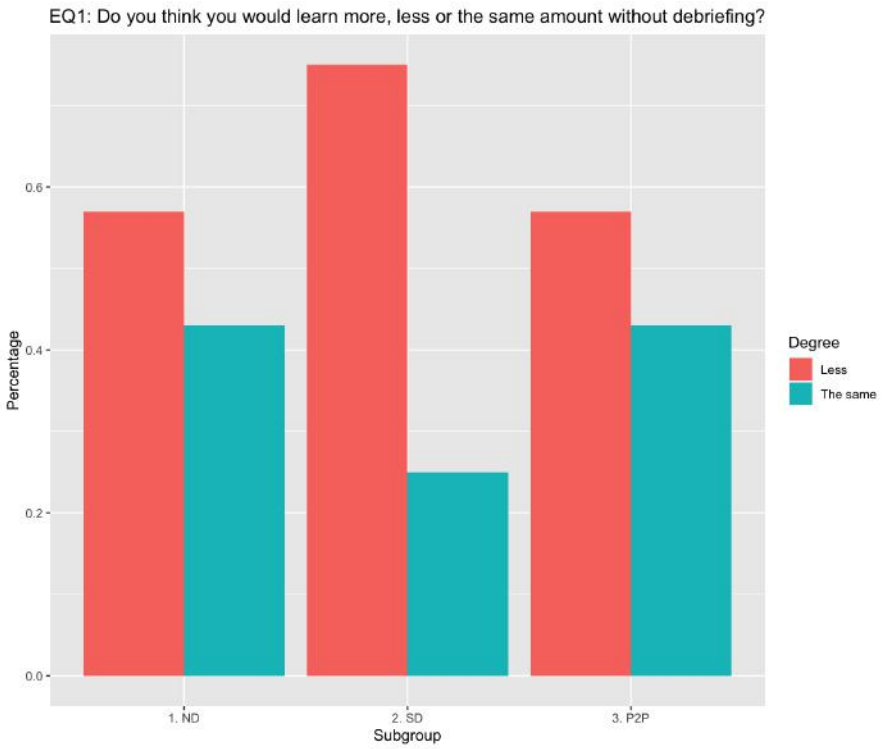


FIGURE 4.11: EQ1

Opinions on debriefing after VR

Item EQ2 explored the general consensus about debriefing after a VR simulation. Of 14 answers of the ND-group 12 participants are positive, 1 is neutral and 1 is negative. Most of the positive participants mentioned the fact that debriefing increases learning because you can learn from others. Generally speaking, one participant mentions that with debriefing different cases (that have an impact) can be discussed more in depth. Another participant says: *"I always find it useful to discuss with each other how things went"*. The participant with the neutral answer says that the impact of debriefing really depends on what type of lesson it is, indicating that for some lessons debriefing may not be useful at all. The participant with the negative answer states: *"I find it difficult because the instructor does not actually see what you are doing (in VR). So your feedback is not quite true that you get from the instructor."*

The SD-group has 10 positive answers and 2 negative answers. The positive participants mentioned that debriefing can enhance the understanding of the simulation. However, a negative participant does not find debriefing useful unless they have any questions. The other participants experienced debriefing in general as tedious and having too many questions.

The P2P-participants (12/14 answers) have more mixed feelings with 5 positive answers, 4 neutral, and 1 negative. The positive answers mention debriefing being informative, important, useful and it is a good concept/addition. The neutral participants find debriefing to be nice but not special. One participant said: "(*Debriefing is) Always good to do, but depends on the situation whether it has to be long*". The negative participant just wrote down that debriefing is weird.

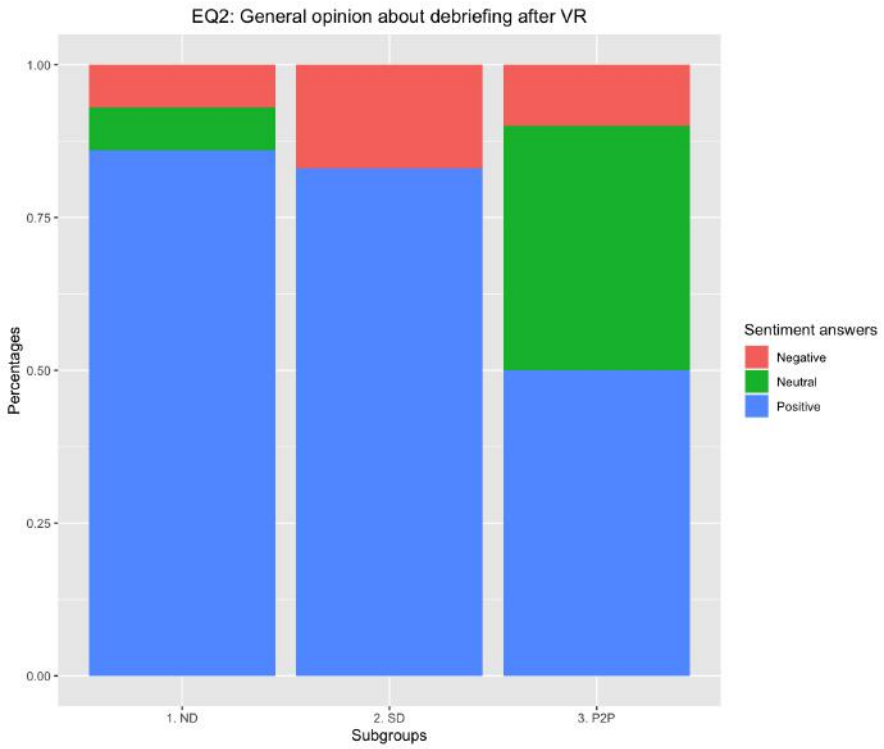


FIGURE 4.12: EQ2

Opinions of saving debriefing answers

Item EQ3 discovered if the participants would like to save their debriefing answers if they would use VR more often at the police academy. Of the ND-group, 11 participants want to save their debriefing answers and 2 participants do not want to save the answers. The positive participants especially mentioned that it is nice to see progress and growth in their performance. Additionally, the possibility to save questions and feedback would be nice to have. The disagreers do not need to save the debriefing answers because it is personal and they can remember themselves where they need to improve.

Of the SD-group, 8 participants answered that they would like to save their debriefing answers, whilst 5 participants answered they would rather not. The yes-sayers mention being able to track their progress. The negative participants want to keep their progress personal and rather find their own way to keep track of their progress.

The P2P-group has 4 positive answers, and 7 negative answers. Just like the previous groups, the positive participants argue that they would like to track their growth. The negative participants all have different arguments on why they would not like to save their answers. One participant argued that it was just not relevant, and one participant only wanted to save their answer if they would do the VR simulation more often. Furthermore, one mentioned only wanting to save the debriefing for research like this.

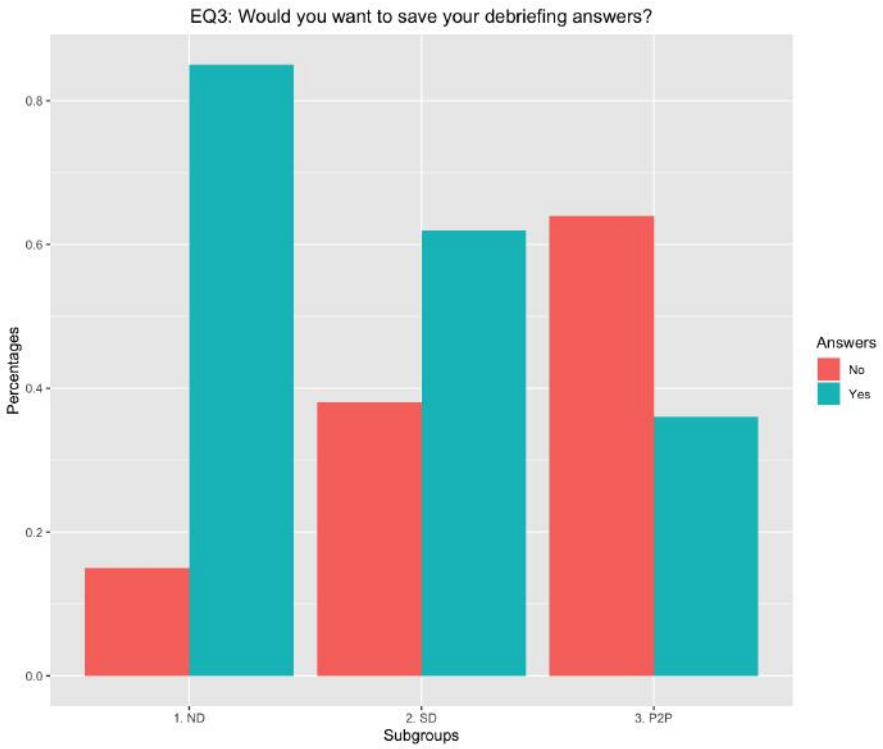


FIGURE 4.13: EQ3

Other remarks

Item EQ4 asked if the participants had any other remarks about the experiment, VRange, or debriefing. This question was answered 16 times in total. 11 participants answered that doing the simulation/experiment was a fun experience. They liked learning in VR and would like to do it more often. As one participant put it: *"Super fun introduction to shooting. So keep this exercise!"*. 2 participants had some technical remarks: A participant mentioned that during the last shooting exercise when they needed to shoot from 10 and 15 meters their view was very blurry. The other participant said the gun did not function well when aiming.
The last three participants had different remarks. One mentioned that VR made them very nauseous. Another participant said that they needed to practice more in/with VRange in order to become better. The last remark was about the usage of VR. The participant argued that shooting may not be the best thing to practice in VR. However, they said VR would be great for practicing with different police cases.

Chapter 5

Discussion

The goal of this thesis is to discover the effect on the learning experience when a debriefing is added after a VR simulation. It is hypothesised that adding some sort of debriefing, whether it is self-debriefing or peer-to-peer debriefing will elevate the learning experience.

In the following section, the results will be further analysed and discussed per measured variable. The main findings are addressed per variable and analysed in the existing literature. Furthermore, the limitations of the study are discussed and future work is presented.

5.1 Knowledge gain and debriefing

Regarding knowledge, literature shows that debriefed students demonstrate score improvements in their performance in comparison to those who did not receive debriefing [36, 58, 63]. Research question 2, *how is the (perceived) knowledge of students influenced by the addition of debriefing?*, tries to look if debriefing leads to a higher knowledge gain of the students after having experienced education in VR.

In this research, all groups report to know more about the National Firearms Safety Protocol (NFSP) after the experiment. When looking at the means of the pre-questionnaire it is noteworthy that the means of the groups differ a lot. The ND-group has the lowest pre-questionnaire mean, followed by the SD-group and the P2P-group has the highest pre-questionnaire mean. This may be a result of the timing of the experiment; the ND-groups and SD-groups did the experiment on the same day, while the P2P-groups were only available 6 school days after the first date. This may have had an effect on the pre-knowledge; the participants had more knowledge before starting the experiment. The higher pre-knowledge of the P2P group is also apparent for items K3 and K4 (fig. 4.1, 4.2), which asks the participants if they are familiar with the two disciplines of the NFSP. All the participants of the P2P group were already familiar with both disciplines when looking at the pre-questionnaire results (table 4.2). In contrast, the other groups contained many participants who were not familiar with the disciplines before the experiment. Although the pre-questionnaire knowledge mean (item K1) was higher for the P2P-group, there was still a significant difference in the indication of knowledge compared to the post-questionnaire mean. Regarding the other knowledge questions (K5 - K8), all groups improved their knowledge or stayed the same when comparing the different pre- and post-questionnaire items. The improvements demonstrate that all groups increase their knowledge after experiencing VRange and not because there is a form of debriefing after the simulation.

The way knowledge is measured may also have an effect on the results. There was only a short amount of time between the pre-questionnaire and the post-questionnaire, and the exact same knowledge questions were asked. The effect debriefing has on the knowledge gain may have been greater if there was a longer time period between the measurements. However, this was not possible for this kind of research because the students would continue with shooting education after the experiment, and it would not be clear if the newly gained knowledge originated from this experiment or the traditional education methods.

In the analysis of open question EQ1, which explores the qualitative perception of knowledge gain among students, all groups report thinking they would learn less without debriefing. The SD-group participants display the highest percentage of individuals who believe they would learn less without debriefing compared to the percentages reported by the other two groups.

Together, these findings suggest that there was knowledge gain after the experiment, but it cannot be determined if the addition of debriefing leads to a greater knowledge gain.

5.2 Self-efficacy and debriefing

The research question for this item was: *How does self-efficacy of police academy students change after completing the VR firearm training module with self-debriefing, group debriefing, or without debriefing*.

For this variable, I hypothesised that participants who would undergo debriefing would have a higher self-efficacy perception after the VR simulation. For all groups, most of the answered questions do not have a significant difference when comparing the post-questionnaire answers to the pre-questionnaire answers. This means that the answers stayed roughly the same, indicating that VRange nor the debriefing had a big impact on the overall self-efficacy of police academy students following firearm lessons.

Zooming in on the results, the ND-group has a significant improvement for self-efficacy for 4 out of the 9 self-efficacy questions, the P2P-group has a significant result for 3 of the 9 questions, and the SD-group for 2 out of the 9 questions. It is remarkable to see that the ND-group had the most questions with a significant difference between the two conditions, contrary to what was hypothesised. All groups had a significant difference for SE1 and SE2. Both questions revolved around whether the participants had more confidence in understanding the firearm protocol. It is thus of no surprise that all groups have a higher self-efficacy for these questions because the VRange module focused mainly on the understanding of the protocol. The results of these two questions for all groups prove that simulators and simulations can lead to effective learning and a higher self-efficacy [19, 23, 34], and not necessarily because of the addition of debriefing at the end of the experiment.

Question SE3, which asked the participants if they believed they would receive an excellent grade for the shooting education, had a significant result for the ND-group and the P2P-group. These groups believed after the simulation that they would receive a higher grade for the course compared to before the experiment. Because the non-debriefed group as well as the debriefed group had a significant result, it cannot be concluded that the addition of debriefing leads to participants believing they will receive an excellent grade for this course.

Question SE4 (I am certain I can understand the most difficult materials presented in the readings for this course) only differs significantly for the ND-group. This group is thus more certain than before the simulation they would understand the most difficult materials presented in the readings for this course. According to the literature, it was assumed that debriefing makes the assignment and objectives of the course clearer through reflection [72], however, these results contradict this.

Research on self-efficacy in combination with VR has already shown mixed results; in section 2.2.1 there was a study where self-efficacy improved after VR [11], where it made no difference [65], and where the self-efficacy even declined [24]. The idea of adding debriefing was to make sure that the self-efficacy of the students would increase. The addition of debriefing would in theory add more reflection to the learning process and through the addition of reflection, learners would believe more in their capability to achieve specific objectives, which would ultimately increase their confidence [6].

5.3 Motivation and debriefing

The sub-question for the motivation variable was as follows: *How does the intrinsic motivation of police academy students differ after completing the VR gun training module with self-debriefing, group debriefing, or without debriefing*?

I hypothesised for motivation that the groups that had a debriefing would have a higher learning motivation compared to the ND-group. Conducting a debriefing after a VR simulation can improve learners' engagement [13], and can boost learners' confidence which is again important for learners' motivation [6]. Out of the 10 questions about motivation, only item IMI7 has a significant result; Item IMI7 asked the participants whether it was important for them to do well in VRange. The P2P-participants agreed more strongly with this statement compared to the ND-group that was not debriefed (figure 4.4). The other groups had also a pretty high score for this item. It may be the case that the P2P-group had more knowledge about handling a firearm because of their pre-knowledge. This resulted in them putting more pressure on themselves while doing the experiment because they were already more knowledgeable.

5.4 Perceived usefulness and debriefing

For perceived usefulness, the sub-question was as follows: *How does the perceived usefulness of VR technology differ for police academy students after completing the VR gun training module with self-debriefing,*

group debriefing, or without debriefing? I hypothesised that the perceived usefulness of the VR simulation would be higher for the debriefing groups compared to the ND-group.

Debriefing could give more meaning to the simulation because it guides learners to recall, evaluate and conceptualise their actions and decisions [37]. They are more aware of what they have experienced and may therefore perceive the experienced simulation as more useful. The perceived usefulness questions had no significant results when comparing all groups at the same time. However, for TAM2, an item that asked participants if VRange would improve their shooting performance, there was a significant difference between the ND-group and the self-debriefing group. The self-debriefing group agreed more with the statement. The mean rank of the P2P-group was also higher than the ND-group but the difference was not significant. It could be the case that the participants are more aware of their in-simulation performance. Debriefing helps to address misunderstandings the participants may have encountered in the simulation. Understanding what went wrong boosts the learners' confidence in their ability to achieve the specific goal [6], in this case, to be able to complete the firearm course.

5.5 Debriefing after VR training

The debriefing variable was used to answer RQ6: *What are the possible limitations and challenges of integrating debriefing in the VR gun training module for police academy students?* The debriefing questions from the DES questionnaire tried to discover if there were any differences in the experienced debriefing of the SD and P2P groups. The goal of using this questionnaire is to discover how debriefing can be best used after a VR simulation. There are 3 items where the difference between the two groups came back with a significant result. For each of these items, the result of the SD-group is higher compared to the P2P-group. The first item with a significant result is DES8, which asked the participants if debriefing helped them become more aware of their role as police officers. The SD-group says debriefing helps them to become more aware of their future profession. This can be a result of the SD-group being more reflective/at ease during the experiment.

The second item with a significant result is DES11 which asked the participants if there was sufficient guidance during the debrief. The P2P-group reports a lower mean rank compared to the SD-group. Both groups received the same questions, the only difference was that the SD-group wrote down the answers on paper, answering the questions individually, and the P2P-group needed to discuss the questions in pairs. The dynamic within the two groups during the debriefing part is noteworthy. Whereas the SD-group was very calm during the debriefing session, the two P2P-groups were very loud and restless; it seemed hard for them to take their time to discuss the questions in pairs seriously. Literature already showed that novice learners may not have the knowledge and the experience to self-debrief (individually or in pairs) and would therefore benefit from a debriefing led by an instructor [36]. The P2P-group was ready to tackle the debriefing in pairs. The questions could have been a reason for this because they were straight to the point, and may seem almost too easy; they were designed to help the students to reflect on their experience in depth.

The last item with a significant result was item DES12 which asked if debriefing gave the participants a way to reflect on their actions during the simulation. Again, the participants from the SD-group agree more strongly with this statement compared to the P2P group. The results of item DEQ, which asked participants from both debriefing groups about their opinion on the quality of the debriefing questions, showed that the P2P-group is less positive about the quality of the questions. The difference in satisfaction can be explained by the behaviour of the two different groups during the experiment. Because the SD-group was more calm and more serious during the debriefing, it may have been easier for them to concentrate on the questions and to reflect on the experience.

Remarkably, EQ1, a qualitative question about knowledge gain after a debriefing, showed that each group thought that they would gain more knowledge with a debriefing after the VR module. However, for item EQ2, which asked how participants felt about debriefing, the ND-group was much more positive than the other two debriefed groups. Indicating that the idea of a debriefing is much more appreciated compared to the act of debriefing. This is in line with the sentiment towards debriefing at the National Police, where almost half of the police employees did not indicate a need for a debriefing to close the day [32].

The difference in debriefing quality between the SD-group and P2P-group can also be analysed by question EQ3, which asked participants if they were interested in saving their debriefing answers. The ND-group is very enthusiastic about this and sees this option as very useful. Whereas the debriefed

groups are more skeptical, especially the P2P-group, where the majority do not want their answers to be saved. This again shows the dissatisfaction of the debriefing section of the group.

5.6 Limitations

The conducted research has the following limitations. The first limitation is the group sizes. Because of the specific study design, it is necessary to compare multiple groups with each other. A total of 44 participants participated in the research. However, a bigger group, of 40 participants per group, could result in more significant results. It was not possible to find more participants because it was necessary for this research that the participants had not been in the shooting range but had finished the previous components of their police education. This means that only police recruits who started in January could participate in this research. Furthermore, it was hard to find time in their busy schedule for the experiment. A possible solution for this problem is to conduct research on multiple PA locations in the same time frame to collect more data.

The second limitation of this research is the location and set-up of the experiment. The experiment was conducted in the Dojo of the PA Amsterdam; the Dojo is a room where the students usually get hands-on practice/workout. Using this location may have had an impact on how seriously the experiment was taken. Besides the location, each iteration of the experiment was conducted with 7 or 8 students at the same time. Because of the low level of VR-dexterity of the students due to the low experience levels, there was a lot of troubleshooting during the experiment. There was only one researcher available during the experiment, and there were sometimes multiple students with VR-console problems. This could have worsened the VR experience of the students.

Furthermore, the VRange module was developed by a third party, and it was not possible to change parts of the module to include "VR debriefing moments." Therefore, it was chosen to create debriefing sessions after the VR simulation has ended instead of in the VR environment itself.

5.7 Future work

Students learn in VRange about a protocol and a test. Although mistakes can still be made, there is not much to debrief. Debriefing would be more interesting for VR modules where, e.g., a case is discussed and students have to make more decisions. The debriefing can help to discover differences in decisions between students.

Additionally, the addition of debriefing sessions could be tested at different police academy locations to see if there is a difference between the reception and effects of the debriefing after VR training.

Moreover, the quality of the questions needs to be improved to make the debriefing more meaningful. In this research, the debriefing questions were not received as positive as expected. Together with educationalists, new questions can be drafted. This research shows that the debriefing questions are not one-size-fits-all, and therefore it is important to create tailored questions for simulations.

Chapter 6

Conclusion and Recommendation

As we reach the end of this thesis, it becomes clear that the conducted research made contributions to understanding the impacts of debriefing after an educational VR simulation. The literature study first introduced what training exactly is and how VR training differs from traditional training methods. Afterwards the advantages of using VR training as an educational tool are introduced. Self-efficacy and intrinsic motivation are introduced in this section because of the beneficial effect VR training has on these two variables. Subsequently, debriefing is introduced as a tool to use after VR training; debriefing can also improve the self-efficacy and motivation of students. With debriefing, students have the chance to reflect more on the VR simulation they have experienced. Debriefing is valuable because it guides learners to recall, evaluate, and conceptualize their actions and decisions. This act can result in a more meaningful VR simulation experience and can improve the knowledge, self-efficacy, and motivation of students. Furthermore, the different forms of debriefing are identified and standard debriefing at the police was discussed.

VRange is a VR module, used by the Police Academy, as a virtual environment where the students can train for their firearm training. The research idea comes from considering the advantages of debriefing, the unclear use of VRange, and the usefulness of this debriefing skill for police officers in the future. Therefore, exploring how debriefing can enhance learning seems worthwhile.

A debriefing method has been created based on the 3D debriefing framework. The scope of this research was to only look at student-led debriefing, to maintain the self-study component of the VR module. Three groups of students participated in the research, one that had no debriefing, and two groups that experienced VRange that followed with a debriefing (individually or in pairs). The results and discussion showed the following:

Knowledge

Literature suggests that debriefed students perform better in terms of knowledge gain. The research shows increased knowledge among all groups after the experiment, but the timing of the experiment may have influenced pre-knowledge levels. The results demonstrate knowledge improvement regardless of debriefing, but student perceptions indicate debriefing is valuable for learning. However, it remains uncertain if debriefing specifically leads to a greater knowledge gain in this context.

Self-efficacy

Most of the self-efficacy questions show no significant results for all groups. After zooming in, the non-debriefed group has the most significant results compared to the debriefed groups. Thus, the addition of debriefing does not improve the self-efficacy of police academy students following the VRange module compared to the control group.

Motivation

Literature shows that the novelty of VR increases the motivation of students. Among the 10 motivation questions, only one item showed a significant result, with the P2P-group expressing stronger agreement that performing well in VRange was important compared to the non-debriefed group. The P2P group's higher pre-knowledge may potentially lead to increased pressure to perform well in the experiment.

Perceived usefulness

The overall perceived usefulness showed no significant differences between groups, the SD-group had a significantly higher agreement that VRange would improve their shooting performance compared

to the ND-group. This suggests that self-debriefing may enhance participants' awareness of their in-simulation performance and contribute to addressing misunderstandings, boosting confidence in achieving specific goals like completing the firearm course.

Debriefing

The Debriefing Experience Scale and the qualitative answers gave some interesting results for the last research question. The self-debriefing group, which debriefed individually, scored significantly better compared to the P2P group for three items. Besides, looking at the qualitative answers, the SD-group was more content with the debriefing session. However, the non-debriefed group was most enthusiastic about the idea of debriefing based on the qualitative answers.

Recommendations

The following recommendations can be made. First, debriefing can help students to be more reflective and students do see the benefit of debriefing. However, a module like VRange may not be the best educational tool for a debriefing. The subject matter from VRange is procedural, and although mistakes can be made, there is always a simple solution. Other VR modules, such as simulating a police case on the street, where students can make many choices, may be more suitable for debriefing. Second, debriefing is taken more seriously if conducted individually compared to in pairs. The paired groups gave very negative scores when asked about their opinion on the debriefing. It seems that they did not take the debriefing as seriously as the other self-debriefing group.

Appendix A

Full learning goals

A.1 Main learning objective 1: National firearms safety protocol

If the participant has attended the training then he can explain in his own words what the national firearms and safety protocol is. In doing so, the participant names what measures to take prior to training, such as;

A. Walking discipline and trigger discipline
B. Placement of (double) hearing protection
C. Placement of eye protection
D. Discharge and loading of firearm at designated point
E. Conducting a safety inspection
F. The different types of ammunition and their operation
G. How to place a safety device (stift)

Appendix B

Questionnaires

B.1 Pre-questionnaire

P. What is your participant number?

Demographics

D1. What is your age?
(Text entry)

D2. What is your gender?
Male Female Non-binary Prefer not to say

D3. Have you been on a shooting range before?
Yes No

D4a. Have you shot a gun before?
Yes No

D4b. *If D4a yes* Where?
(Text entry)

D5. How many hours of experience do you have with VR?
No prior experience 1-10 hours 10-50 hours 50-100 hours 100+ hours

Knowledge questions

K1. How much do you know of the LVVP?
Extremely little Very little Somewhat Neutral a little bit ff Eveything

K2. How have you gained knowledge on the LVVP?
I watched Video's on ITsLearning I read the LVVP I heard about the LVVP I did not gain any knowledge on the LVVP

K3. Do you know what walking discipline is?
Yes No

K4. Do you know what trigger discipline is?
Yes No

K5. On which moment is the trigger finger located on the trigger?
(Text entry)

K6. What kind of safety protection is compulsory to wear on the shooting range?
(Text entry)

K7. What is a safe direction to aim the weapon?
(Text entry)

K8. In what ways can you check the condition of the weapon?
(Text entry)

Self-efficacy questions

SE1. I am confident that I understand the full landelijk vuurwapen-veiligheidsprotocol.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

SE2. I am confident that I understand the more complex concepts related to the protocol.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

SE3. I believe I will receive an excellent grade in this class.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

SE4. I am certain I can understand the most difficult materials presented in the readings for this course.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

SE5. I am confident I can understand the basic concepts taught in this course.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

SE6. I am confident I can understand the most complex material presented by the instructor in this course.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

SE7. I am confident I can do an excellent job on the assignments and tests in this course.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

SE8. I expect to do well in this class.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

SE9. I'm certain I can master the skills being taught in this class.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

SE10. Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this course.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

B.2 Post-questionnaire

P. What is your participant number?

Knowledge questions

K1. How much do you know of the LVVP?
Extremely little Very little Somewhat Neutral a little bit Sufficient Everything

K2. How have you gained knowledge on the LVVP?
I watched Video's on ITsLearning I read the LVVP I heard about the LVVP I did not gain any knowledge on the LVVP

K3. Do you know what walking discipline is?
Yes No

K4. Do you know what trigger discipline is?
Yes No

K5. On which moment is the trigger finger located on the trigger?
(Text entry)

K6. What kind of safety protection is compulsory to wear on the shooting range?
(Text entry)

K7. What is a safe direction to aim the weapon?
(Text entry)

K8. In what ways can you check the condition of the weapon?
(Text entry)

Self-efficacy questions

SE1. I am confident that I understand the full landelijk vuurwapen-veiligheidsprotocol.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

SE2. I am confident that I understand the more complex concepts related to the protocol.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

SE3. I believe I will receive an excellent grade for the shooting education.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

SE4. I am certain I can understand the most difficult materials presented in the readings for this course.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree
Agree Strongly Agree

SE5. I am confident I can understand the basic concepts taught in this course.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree
Agree Strongly Agree

SE6. I am confident I can understand the most complex material presented by the instructor in this course.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree
Agree Strongly Agree

SE7. I am confident I can do an excellent job on the assignments and tests in this course.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree
Agree Strongly Agree

SE8. I'm certain I can master the skills being taught in this class.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree
Agree Strongly Agree

SE9. Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this course.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree
Agree Strongly Agree

Intrinsic Motivation

IMI1. VRange was fun to do.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree
Agree Strongly Agree

IMI2. I would describe VRange as very interesting.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree
Agree Strongly Agree

IMI3. I think I am pretty good at VRange.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree
Agree Strongly Agree

IMI4. After working with VRange for a while, I felt pretty competent.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree
Agree Strongly Agree

IMI5. I am satisfied with my performance in VRange.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree
Agree Strongly Agree

IMI6. I put a lot of effort into VRange.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree
Agree Strongly Agree

IMI7. It was important to me to do well in VRange.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree
Agree Strongly Agree

IMI8. I felt very tense while doing VRange.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree
Agree Strongly Agree

IMI9. **R** I was anxious while working with VRange.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree
Agree Strongly Agree

IMI10. I believe this activity could be of some value to me in firearm handling.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree
Agree Strongly Agree

Perceived Usefulness

TAM1. Using VRange would enhance my knowledge of the LVVP.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree
Agree Strongly Agree

TAM2. Using VRange would improve my shooting performance.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

TAM3. Using VRange enhances my learning-effectiveness.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

TAM4. I find VRange useful.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

Debriefing questions (Only for SD and P2P groups)

DES1. Debriefing helps me to analyze my thoughts.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

DES2. Debriefing confirmed the decisions I made in the virtual simulation.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

DES3. Debriefing helped me to make connections in my learning.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

DES4. Debriefing was helpful in making sense of the virtual simulation.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

DES5. Debriefing provided me with a learning opportunity.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

DES6. Debriefing helped me to find meaning in the virtual simulation.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

DES7. My questions from the virtual simulation were answered by debriefing.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

DES8. Debriefing helped me become more aware of my role as a police officer.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

DES9. Debriefing helped me to clarify problems.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

DES10. Debriefing helped me to make connections between theory and clinical practice.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

DES11. There was sufficient guidance during the debrief.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

DES12. Debriefing gave me a way to reflect on my actions during the simulation.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

DES13. I Had enough time to debrief thoroughly.
Strongly disagree Disagree Somewhat disagree Neutral Somewhat agree Agree Strongly Agree

B.2.1 Exploratory Questions

NDEQ. Do you think you would have needed a debriefing moment after the simulation? Why/why not?
(Text entry)

DEQ. What did you think of the debriefing questions? What did you like and what could be improved?
(Text entry)

EQ1. Do you think you would learn more, less or the same amount without debriefing? Why?
(Text entry)

EQ2. What is your opinion about a debriefing in general after a Virtual Reality simulation?
(Text entry)

EQ3. If you used VR more often at the police academy, would you like to save your debrief answers? Why or why not?
(Text entry)

EQ4. Do you want to say anything else about the experiment, VRange or the debriefing?
(Text entry)

Appendix C

Visualization of Knowledge questions K5 to K8

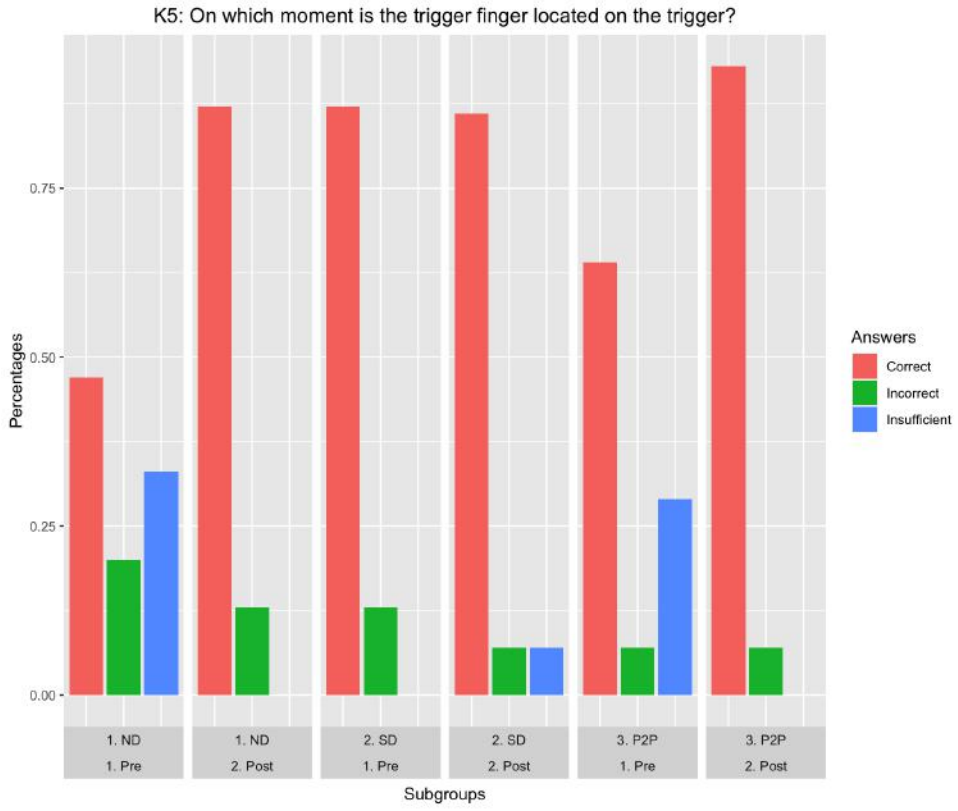


FIGURE C.1: K5

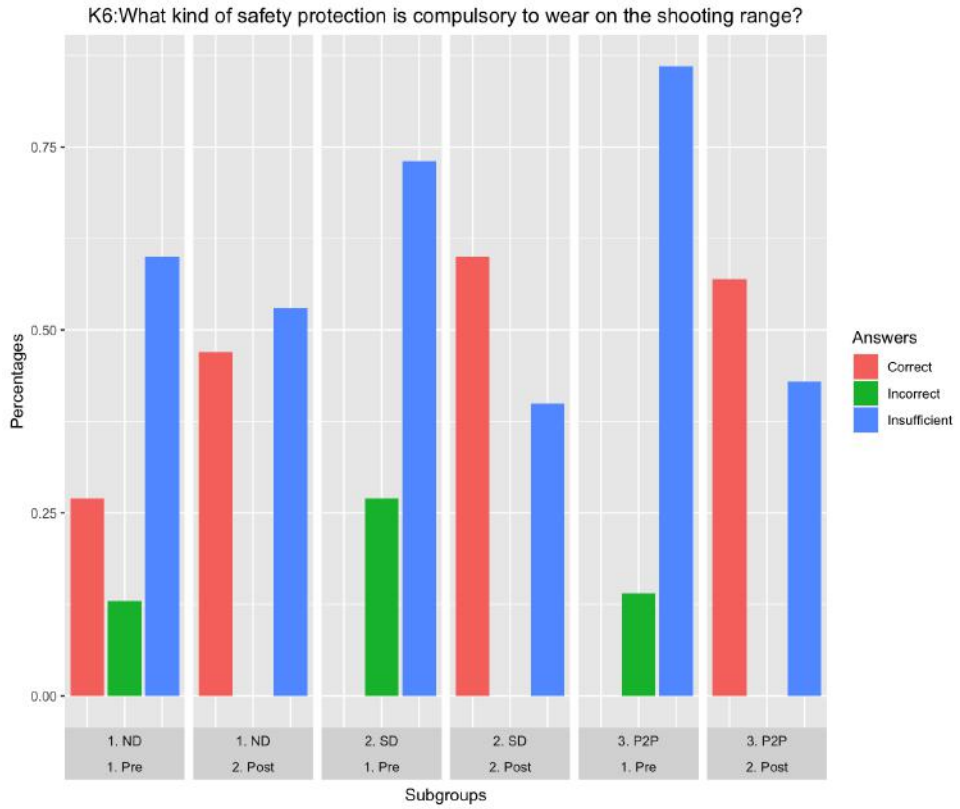


FIGURE C.2: K6

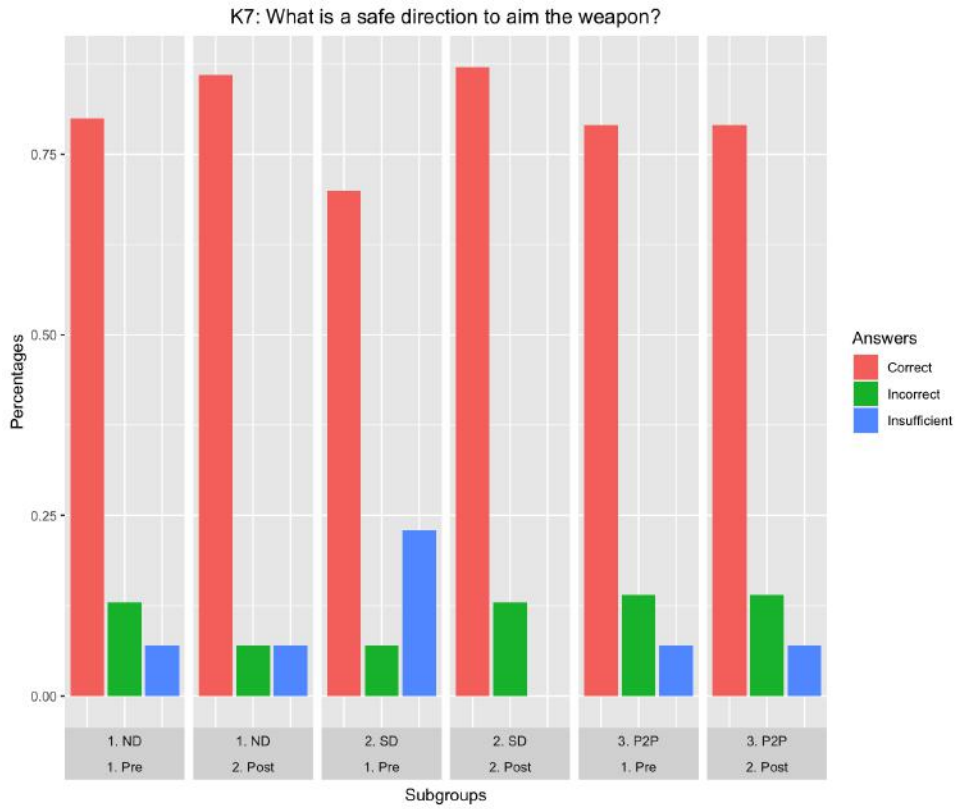


FIGURE C.3: K7

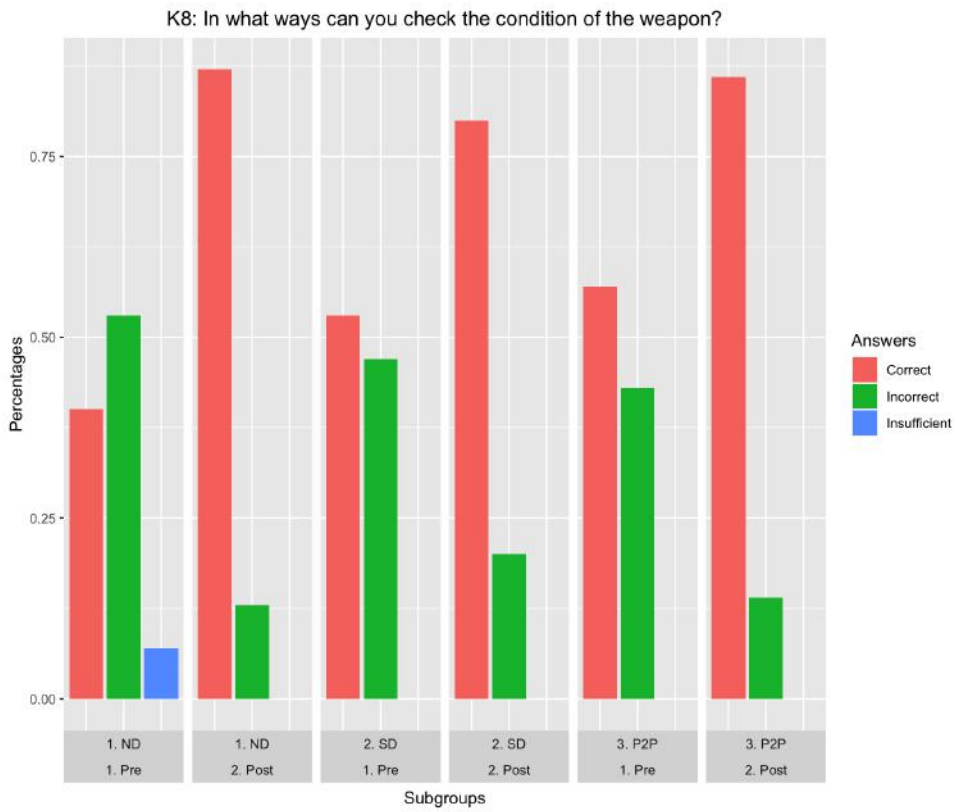

K8: In what ways can you check the condition of the weapon?
Percentages
0.75
0.50
0.25
0.00
1. ND
1. Pre
1. ND
2. Post
2. SD
1. Pre
2. SD
2. Post
3. P2P
1. Pre
3. P2P
2. Post
Subgroups
Answers
Correct
Incorrect
Insufficient

FIGURE C.4: K8

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