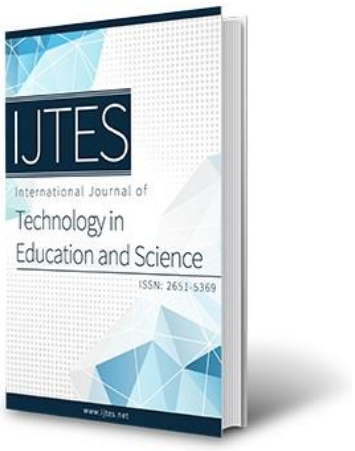


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# Creating VR Content for Training Purposes

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## Abstract

This work provides an overview of the use of Virtual Reality (VR) technology in the context of training through the documentation of a project produced by Ohio University's Game Research and Immersive Design (GRID) Lab involving the development of a cine-VR series for police officer training in areas such as suicide prevention, mental health, crisis intervention, domestic violence resolution, and school violence prevention. The article starts by introducing the concept of VR training with its subdivisions and its benefits, including the promotion of learning and empathy through immersion. Followingly, it describes the process of planning for a VR training. Subsequently, it breaks down the several stages of creating VR training content from scenario exploration, scriptwriting, recording, to postproduction. In conclusion, this paper recognizes the challenges of creating compelling VR content such as storytelling, editing, and resources. Additionally, it attempts to pave the way for similar VR training projects by providing recommendations and emphasizing the importance of communication, adaptability, and experimentation.

## Theoretical Background

### Defining VR Training

The emergence of virtual reality (VR) training has revolutionized the field of professional education and development across various industries. By offering immersive and realistic scenarios, VR training provides a unique learning experience that replicates real-world environments, allowing trainees to fully engage in a 360-degree interactive setting (PIXO VR, n.d.). While wearing head-mounted gear with embedded displays, users enjoy the freedom of perspective since they can look around as they would in real life, compared with traditional video content where perspective is fixated on a monitor.

In addition to headsets, designers of VR training can incorporate additional accessories such as hand-held controllers, imitations of weapons, a steering wheel, or other tools relevant to the topic of the training. Alternatively, users can interact with the virtual environment using their hands if the VR headset is capable of hand-tracking. This innovative approach not only equips employees with valuable on-the-job training (OJT), but also ensures their safety thanks to a controlled risk-free space, leading to enhanced productivity (*VR training*, 2023).

## Subdivisions of VR Training Content

VR technology can meet different training requirements. It encompasses two primary types of content: soft skills training and hard skills training. On one hand, soft skills are effectively addressed through VR simulations that replicate conversations and interactions between individuals. This form of role-play training offers scalability while providing emotionally authentic experiences applicable to diverse fields such as customer service and sales (Talespin team, 2023). On the other hand, hard skills-focused VR training emphasizes the refinement of technical competencies and processes like machinery assembly or adherence to safety protocols. Industries such as healthcare, financial services, insurance technology, and energy significantly benefit from this type of specialized instruction (Talespin team, 2023).

Moreover, VR training content can be broadly categorized into two main types: video-based content recorded using advanced cameras capable of capturing full panoramic views (360° videos) and computer-generated simulations designed explicitly for VR experiences. Surround 360° video-based content immerses trainees in real-life scenarios, offering a realistic and immersive experience, replicating real-world processes and tactics (Cleverdon, 2020). The use of computer-based VR simulation resembles serious gaming, where trainees engage with carefully staged simulated environments targeting specific skill sets. This serves the purpose of preparing individuals for tasks that would pose risks or prove impractical in real-life scenarios. According to Fedko (2023), VR training development can also require content such as 3D environments to create a realistically rendered background, animations to provide an excellent user experience, virtual characters, video and sound effects to make training programs more authentic, and voice-overs that instruct and guide trainees to complete the session properly.

Apart from employee training, VR simulation holds significant importance in healthcare, education, and professional development. Creating immersive and interactive environments devoid of real-world consequences provides a safe space for users to practice and enhance a wide range of skills (Talespin team, 2023; Capsim, 2021). In the field of healthcare, VR simulation enables medical professionals to refine their expertise by practicing complex procedures without endangering patients' lives (Bowditch & Williams, 2022; Patel et al., 2020). Surgeons can virtually perform surgeries which bolsters confidence while reducing the likelihood of errors during actual operations. (Clarke, 2021; Surgical Science, n.d.). Within educational settings and professional development (PR) programs, VR simulation introduces an innovative approach to augmenting technical competencies and non-technical skills. Learners are afforded opportunities to cultivate leadership abilities and improve communication aptitude, thereby facilitating organizational learning objectives (Talespin team, 2022; Nassar et al., 2021).

To conclude, the advent of VR training heralds the transformative prospects related to skill acquisition endeavors across various sectors. The continued evolution of technology has been ceaselessly widening its horizon and extending its diversity, further enhancing learning experience while improving proficiency attainment. This trajectory presents exciting possibilities when considering future applications.

## Benefits of VR Training

Thanks to its versatility, experts from different backgrounds have been exploring the potential applications of VR technology in training which has proven to be a time and money saving alternative to traditional employee training methods (Capsim, 2021). While training in real environments can be dangerous and expensive, rendering it counterproductive, studies about the use of VR for educational and community engagement purposes (Calil, 2021; Queiroz, 2023) through simulated scenarios have shown that it presents a safer cost-effective alternative. In addition to initial cost reductions, VR technology eliminates the requirement for physical prototypes, providing consistent training experience and resolving logistical obstacles linked to extensive exercises (Wrap Technologies, 2023).

VR training provides a controlled, immersive environment that eliminates safety concerns and enhances user engagement. Huston & McGinley (2023) investigate the potential of using virtual environments "to cater to the specific needs and preferences of introverts and those with ASC" (p. 409), and they conclude that VR presents a comfortable safe space for experiencing social interactions. They add "In a rapidly changing world, the metaverse and VR technologies hold the promise of bridging gaps and connecting people in ways never before possible, ultimately contributing to a more inclusive and understanding society" (p. 410).

The implementation of VR simulations drastically reduces time requirements associated with developing competency levels. In his review of how the Internet of Things is transforming education, Meylani (2024) deduces that Augmented Reality (AR) and VR improve student comprehension, interest, and retention of course material. It offers consistent yet budget friendly means for delivering comprehensive instruction, thus minimizing reliance on utilizing live subjects or patients (Surgical Science, n.d.). Such measures also enable learners to safely navigate potentially hazardous circumstances without exposing themselves to danger.

VR training can be fully customized by the team of designers who may research the context of the program, pick the best hardware, and develop a program that matches the training policies of the client and caters to their needs (Fedko, 2023). For instance, NASA started developing its first VR simulation to train astronauts as early as 1989, before inaugurating its VR lab in 1991 (Virtual Reality Society, n.d.). In addition to cognitive and attitudinal learning, VR can be used to hone motor skills. Roche and Gal-Petitfaux (2017) state that video-enhanced environments or 360° video hold promising potential for training teachers of physical education. By emulating real-world scenarios within a secure virtual environment, students acquire practical proficiencies while honing problem-solving capabilities alongside critical thinking prowess (Talespin team, 2022; Talespin team, 2023).

The unique experience, made possible by VR, converts passive viewers into active ones as it places them in realistic environments with an increased sense of presence (Violante et al., 2019), which reflects positively on the learning outcome. Langer (2023) argues that AR and VR have high potential for knowledge transfer and relates it to Immersive Storytelling and Immersive Experience as success factors. This goes in line with the conclusion of Dick et al. (2014) that similarity between the learning context and the performance context promotes efficient transfer of learning. Dick et al. (2014) further explain that educational materials evoking "empathic identity with

the character observed or portrayed" (p.192), which implies immersive storytelling, promote learning, especially when it comes to attitudes.

Bowditch & Williams (2022) investigate the use of cine-VR in training healthcare providers with topics such as diabetes and drug addiction, and they deduce it is an effective method for cultivating empathy. In a different context, Aimiuwu (2022) explores using a combination of VR and AI in promoting social justice, and he describes VR as "excellent for capturing multi-dimensional and multisensory videos, sounds, and pictures that can help police and judges to conclude exactly what happened" (p. 32). Additionally, he introduces the term telepresence as the state of being virtually transplanted to a scene and concludes that witnessing events in VR, similar to how they were occurring in real life, allows the user to grasp the verbal and physical abuse implied.

In conclusion, VR is a versatile tool that boosts knowledge transfer thanks to the realistic active experience it provides to the learner. VR is suitable for different types of learning, and it promotes empathy. Compared to others, VR is a safer and cheaper option. For these reasons and more, we believe VR is a good fit for police officer training.

## Planning for a VR Training

### A Multifaceted Solution for Law Enforcement Training

Law enforcement agencies consistently strive to develop novel methods to improve the caliber and efficiency of their training programs. The foundation of law enforcement education has historically been traditional police training, which combines classroom learning with practical experience. This highly embraced and commonly known strategy provides face-to-face communication and a sense of regularity and consistency. Nevertheless, its disadvantages encompass high costs, lengthy time requirements, and difficulties in expanding its scope. Moreover, the instructor's knowledge and skill can influence the quality of instruction (Bauert, 2023).

VR 360-degree video training represents a significant shift in perspective. It enables police officers to engage in immersive and interactive real-life circumstances within a controlled and supervised setting. This technology-centric approach holds the potential to ensure that every trainee receives uniform training of high standards (Bauert, 2023). Research suggests that VR training is more effective than traditional techniques in improving memory and skill retention. It also provides a time-efficient alternative to traditional training methods (Hayes, 2023; Immersion VR, 2022). VR training offers a favorable answer from a cost standpoint. Although the initial cost of investing in VR technology is substantial, it can be balanced out by long-term cost reductions. VR prevents the necessity for tangible prototypes and mitigates the logistical difficulties linked to extensive training drills, as evidenced by significant financial savings documented by clients (Bauert, 2023; Hayes, 2023).

Ensuring user satisfaction is of utmost importance, and VR training surpasses expectations in this aspect. According to a study conducted by PricewaterhouseCoopers, 78% of learners prefer VR learning because of its complete immersion, engaging nature, and unique experience (Future Visual, n.d.). The immersive and authentic experiences offered by VR captivate officers in ways that conventional approaches frequently find challenging to

accomplish (Crew, 2023; Wrap Technologies, 2023). VR training provides a comprehensive method for enhancing skills, surpassing simple yes-or-no choices. The platform serves to boost situational awareness, instruct de-escalation tactics, and improve communication abilities (Crew, 2023; Friese, 2023). VR technology allows law enforcement officials to cultivate essential decision-making abilities and emotional intelligence within a controlled virtual setting, which is particularly valuable in the current policing landscape where quick judgments are of utmost importance (Wrap Technologies, 2023).

The incorporation of VR video training in law enforcement emerges as a versatile and comprehensive option. The realism and safety of this technology allows officers to practice in high-risk circumstances, such as active shooter incidents and hostage scenarios (Koenig, 2021). VR also aids in mitigating unconscious bias, enhancing communication, and offering a thorough evaluation and feedback system for performance assessment (Parnofiello, 2020). Conventional police training methods demonstrate familiarity and face-to-face connection, but they are plagued by expense and consistency problems. Contrarily, VR training stands out due to its authentic situations, economical nature, and unwavering training excellence. The evaluation of flexibility and performance further establishes VR training as a strong competitor in the advancement of law enforcement education (Bauert, 2023; Smythe, 2021).

**OPOTA and the VR Revolution**

The Ohio Peace Officer Training Academy (OPOTA), a renowned institution in the field of law enforcement education, is adapting to the changing environment by delving into the realm of VR instruction. Recognizing the potential of VR to address implicit bias, enhance de-escalation techniques, and create a secure learning environment, the OPOTA modifies its methods to make use of the advantages offered by immersive experiences (Parnofiello, 2020; Smythe, 2021; Fleming, 2023).

The VR training project dubbed “Ohio 360” is led by Ohio University's GRID Lab and receives funding from the Ohio Attorney General. “Ohio 360” aims to establish a nationwide cine-VR library, with a primary focus on de-escalation tactics, to make affordable training accessible to police enforcement officers on a large scale (Williams & Bowditch, 2023). This concept acknowledges the budgetary limitations faced by smaller police departments and promotes a hybrid strategy that combines cine-VR technology with tailored community-level training. Developing a nationwide training program requires recognizing the legal and environmental differences that exist among states, regions, and departments. The lack of a standardized police training curriculum across the country highlights the necessity for being able to adjust and modify accordingly. The present digital technology provides a cost-effective nationwide training program that may accommodate agencies of any size or location (Williams & Bowditch, 2023).

The examination of traditional and VR police training methods reveals a dynamic environment where innovation intersects with tradition. Although traditional methods offer a familiar basis, VR training is emerging as a cost-effective, engaging, and immersive solution. The dedication to adopting technological advancements is exemplified by the joint endeavors of institutions such as OPOTA and programs like “Ohio 360”. The evolution

of law enforcement education promises to combine tradition and innovation to provide a comprehensive and efficient training experience for officers nationwide.

**Goal Statement**

The first step in planning any training, including VR training, is synthesizing the goal statement. In fact, it is in this step that the instructional designer decides whether instruction is the correct approach and whether training is the optimal method. The goal statement must identify the learners, describe the performance context, and precise the performance objectives which are the expression or the realization of instructional goals. Dick et al. (2014) define instructional goals as "clear statements of behaviors that learners are to demonstrate as a result of instruction".

For the project in hand, based on a needs assessment conducted by The George Voinovich School of Leadership and Public Service (GVS), The Ohio Peace Officer Training Academy (OPOTA) assigned an initial task to Ohio University's Game Research and Immersive Design (GRID) Lab which is to produce and curate a library of twenty highly realistic, immersive cine-VR experiences that provide officers an opportunity to practice decision-making and de-escalation techniques in a safe, controlled environment. The resort to VR is justified by the need for the training to be made affordable and available nationwide with urgency. One alternative could have been in-person training which would have been financially, logistically, and legally challenging to distribute on a national level. Another alternative could have been a series of traditional videos or video lectures, but this solution would not be as impactful and influential as needed because it lacks the immersiveness of VR as explained previously.

Hence, the goal statement for this training could be articulated as follows: Police officers will become familiarized with decision-making and de-escalation techniques that they can later apply in various real-life scenarios.

**Instructional Strategy**

According to Williams & Bowditch (2023), the cine-VR content will be distributed through an online platform called "Ohio 360". As the library of experiences expands gradually, it will not replace reality-based training, but rather accompany it. Participants will be able to communicate and interact with one another during and after training. Discussions will be held where they share their analysis of the scenarios and its events. The training will be available synchronously where a group of police officers in a session collectively wear headsets that display content in sync, or asynchronously where any officer attends the experiences individually via "Ohio 360".

The VR experiences will be available in different versions that include different levels of information added as graphic overlays in postproduction. For example, one version might display clues on the feelings of the victim in the scenario, while another one could display the techniques employed by the police officer. Including all this information in the same video sequence would overwhelm the trainee and keep them from feeling immersed. Therefore, spreading out the cognitive load, in addition to watching the scenario repetitively, is expected to have a positive effect on retention.

This instructional strategy of the training could be organized with relation to Gagné's events of instruction (1985) as follows:

1. Gaining attention: police officers are sensitized by the gravity of the topics or the scenarios, and they might feel curious to try VR.
2. Informing learners of the objectives: police officers are informed that the training aims to reduce the unnecessary use of force and to increase the effectiveness of police intervention.
3. Stimulating recall of prerequisite learning: police officers can share previous encounters and discuss relevant cases to summon pre-existing knowledge.
4. Presenting the stimulus material: police officers watch the cine-VR content.
5. Providing learning guidance: police officers receive additional information on the techniques employed in the scenarios while and after watching.
6. Eliciting the performance: police officers practice by simulating the scenarios in the training session.
7. Providing feedback about performance correctness: police officers receive feedback from the training supervisor as well as their peers.
8. Assessing the performance: the police officers' performance is assessed at the end of the training by the training supervisor, and they are also encouraged to self-reflect.
9. Enhancing retention and transfer: this is achieved through the multimodality of the training as trainees receive a supporting manual (described followingly in the paper).

## Creating VR Training Content

### Scenario Exploration

Scenario exploration is a crucial element of VR training content. It entails the generation and modification of virtual scenarios to enhance learning and the acquisition of skills. To begin scenario exploration, the initial stage is identifying the learning objectives. The design of the virtual situations is guided by these aims to ensure that they are in line with the anticipated learning results (Mantovani et al., 2003). As an example, in a VR training program designed for firefighters, the primary goals of learning may be comprehending the principles of fire behavior, rehearsing emergency procedures, and honing the ability to make critical decisions in high-stress situations.

Furthermore, the scenarios are meticulously crafted to closely mirror real-life circumstances. This entails the creation of authentic virtual settings, characters, and events. Employing appropriate graphics and music can heighten the feeling of being there, thereby rendering the training experience more captivating and efficacious (Slater & Wilbur, 1997). As previously mentioned, interactivity is a fundamental characteristic of VR settings. Trainees must be able to engage with the virtual world and obtain feedback on their actions. Empirical evidence shows that this method of active learning enhances knowledge retention and acquisition of skills (Winn, 1993). In the fireman scenario, students would engage with virtual tools, traverse a blazing structure, and formulate judgments based on dynamic fire simulations.

Scenario research entails diversifying the framework to encompass a broad spectrum of conditions and obstacles.

The diversity in training helps individuals adapt to the unpredictable nature of real-world work and facilitates the application of abilities learned in virtual environments to real-life situations (Kozlowski et al., 2001). The process of scenario exploration should incorporate methods for evaluating and providing input. The behaviors of trainees in VR scenarios can be monitored and evaluated to gauge their performance, offer feedback, and pinpoint areas that need development (Gavish et al., 2015).

Here are some examples that demonstrate the wide range of application for VR in training, including the development of soft skills and technical training in different industries (Virtual Reality Training Examples to Inspire Your Training Programs, n.d.):

- The Psychological Safety Module is a VR training module that specifically addresses the concept of psychological safety.
- The Virtual Leadership Module aims to improve leadership abilities within a virtual setting.
- The Effective Behavioral Feedback Module is a VR training module that focuses on teaching individuals how to deliver feedback on behavior effectively.
- The Conflict Resolution Module utilizes VR technology to provide participants with training on effective ways to resolve conflicts.
- The Supportive Leadership Module is designed to enhance and cultivate supportive leadership abilities.
- BMW utilizes VR technology to train its employees in design and prototyping, with a specific focus on safety. The training encompasses the implementation of lean manufacturing techniques to optimize factory operations.
- Peugeot uses VR technology to provide comprehensive training to their staff, ensuring optimal efficiency and a strong emphasis on safety.
- Audi uses VR technology to provide meticulous training to their personnel in handling intricate systems.

**Writing Script for 360-Degree Video**

The development of VR training content is an intricate undertaking that necessitates meticulous preparation and implementation. Writing the script, which acts as the fundamental structure of the training material, plays a pivotal part in this procedure. Before developing a VR screenplay, it is imperative to establish the training objectives. The objectives should adhere to the SMART criteria, which stands for Specific, Measurable, Achievable, Relevant, and Time-bound (Bailenson, 2018). They act as the guiding principle for the script development and ensure that the VR training content efficiently achieves the targeted learning results. Comprehending the VR medium is an additional crucial facet of scriptwriting.

Scripting for VR diverges from conventional genres. VR is a medium that provides an immersive and interactive experience, enabling users to explore and interact with a virtual environment in ways that are not achievable through conventional media (Rizzo & Koenig, 2017). Within the realm of VR, the user assumes an active role in the narrative rather than only observing passively. Hence, the script should welcome user autonomy and offer chances for exploration and interaction within the all-encompassing 360-degree environment. Brillhart (2015) invites screenwriters and VR creators to “embrace a visitor’s freedom as an asset rather than a curse” and “to

leverage rebellion and curiosity instead of rejecting it" (paragraph. 5). This not only improves the learning experience, but also heightens the level of user involvement. The concept of spatial storytelling is crucial in the field of VR scriptwriting. It utilizes the 360-degree environment to construct narratives that envelop the user, generating a feeling of being present and fully engaged (Dooley, 2018). The script should direct the user's focus through visual and audio prompts while simultaneously permitting independent inquiry.

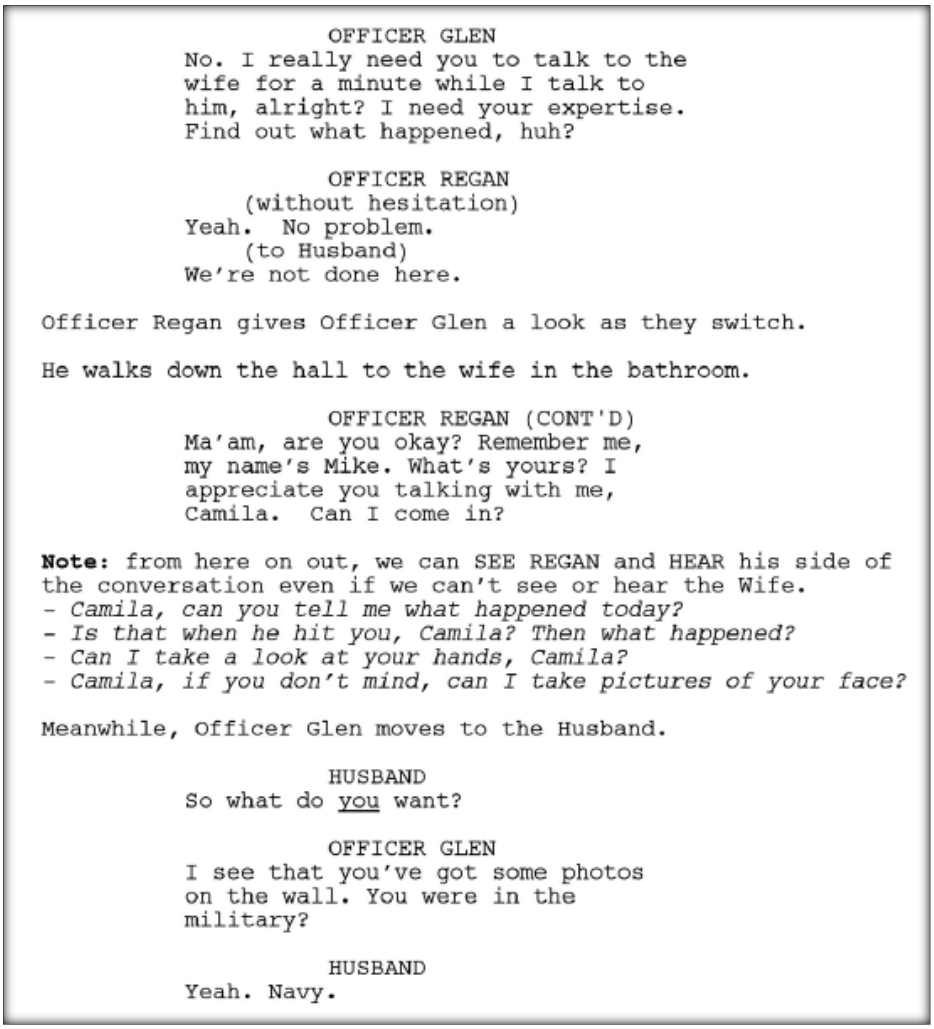
When composing the script, it is crucial to consider the target audience. The script language, style, and difficulty should be customized based on the audience's existing knowledge, abilities, and learning preferences (Bozgeyikli et al., 2016). This guarantees that the VR training content is suitable and advantageous to all users. Furthermore, the script must consider the technical and physical limitations and challenges of VR. It is important to account for factors such as motion sickness, user comfort, and accessibility (LaViola Jr et al., 2017).

In the case of the project covered by this paper, 6 scripts were written by Eric R. Williams, assisted by 8 content experts, as part of "Virtual Series I: Reality of Policing". Each script deals with a different topic and constitutes an independent experience. The topics include, but are not limited to, de-escalation, importance of debriefing, persons in crisis, duty to intervene, managing agitation, first amendment auditors, officer wellness, and constitutional policing. The episodes are entitled: Investigative Detention in Harding Park, Jumper on High Plains Bridge, Domestic Violence On Oak Street, Pink Slip Issued On Runway Drive, Well-Being Check In Indian Hills, and Shots Fired At C.W. High.

The scripts range between 9 and 14 pages in length, and the episodes are 5 to 12 minutes long. In total, 56 minutes of content were created based on 71 script pages. On average, a single page of script converted to 47 seconds of footage. This is justified by the high amount of stage directions and audio-visual clues that VR scriptwriting requires. Because the field of vision is 360°, everything taking place on the scene has to be accounted for. Certain parts of the script were written in dual-dialogue format when there were multiple conversations unfolding simultaneously.

For example, Figure 1 is taken from the script of "Domestic Violence On Oak Street", and, in this scene, the primary area of focus is the interaction between Officer Glen and the suspect (Tommy, the husband). Additionally, there is a secondary area of focus which is the exchange between Officer Regan and the victim (Camila, the wife) taking place in the other room. The viewer can turn around and shift their attention to either conversation at any moment. Hence, the dialogue has to be well-studied in both instances.

After the completion of the initial draft or version of the script, it is imperative to subject it to scrutinization and further revision, considering any comments received. This iterative method aids in discovering and correcting any deficiencies or discrepancies in the script, in the hopes of guaranteeing optimum efficiency of the VR training content and alignment with the training objectives (Lorenzo et al., 2013). The scripts in the OPOTA cine-VR training series are reviewed by multiple experts from Athens Police Department, Athen's County Sheriff's Office, Ohio University Police Department, Columbus Police Department, Columbus Division of Police, Ohio Attorney General's Office, and Ohio Peace Officer Training Academy.



OFFICER GLEN
No. I really need you to talk to the wife for a minute while I talk to him, alright? I need your expertise. Find out what happened, huh?

OFFICER REGAN
(without hesitation)
Yeah. No problem.
(to Husband)
We're not done here.

Officer Regan gives Officer Glen a look as they switch.

He walks down the hall to the wife in the bathroom.

OFFICER REGAN (CONT'D)
Ma'am, are you okay? Remember me, my name's Mike. What's yours? I appreciate you talking with me, Camila. Can I come in?

**Note:** from here on out, we can SEE REGAN and HEAR his side of the conversation even if we can't see or hear the Wife.
- *Camila, can you tell me what happened today?*
- *Is that when he hit you, Camila? Then what happened?*
- *Can I take a look at your hands, Camila?*
- *Camila, if you don't mind, can I take pictures of your face?*

Meanwhile, Officer Glen moves to the Husband.

HUSBAND
So what do you want?

OFFICER GLEN
I see that you've got some photos on the wall. You were in the military?

HUSBAND
Yeah. Navy.

Figure 1. Script Extract from the Episode Entitled "Domestic Violence On Oak Street"

**Recording and Camera Setup**

Radisek (2023) explains that the creation of VR content often consists of three stages: defining the objective of the program, generating assets, and constructing the project using an authoring tool. He adds that for computer generated content, Unity and Unreal Engine are the two most potent and prominent VR creation tools. Meanwhile, in cine-VR, the broad domain to which the OPOTA project belongs, filming and camera setup are essential to the process of producing assets and advancing the project. When recording for VR, the camera takes footage in diverse immersive formats. The cameras are offered in both consumer and professional variants, with the selection being determined by the formats, feature sets, and price (Meta Quest for Creators, 2022a). Professional developers can utilize diverse combinations of these technologies to produce immersive VR experiences of commendable quality. For instance, Heuke genannt Jurgensmeier et al. (2023) describe the process of creating 360° images for use in the educational sector as Virtual Field Trips, and they conclude that the choice of shooting equipment, editing software, and display device all have an effect on the level of immersion.

VR filming diverges dramatically from conventional video production. VR involves the camera recording a whole 360° perspective of the surroundings, resulting in a highly engaging experience for the viewer. This necessitates

grounded strategizing and implementation. The camera ought to be positioned at the focal point of the activity, with all noteworthy occurrences happening within the visual range of the camera, meaning not too far nor too close nor behind an object. To ensure a natural viewpoint for the viewer, it is crucial to maintain a steady camera height, usually at eye level (Mantello, 2020). Numerous camera configurations are accessible for 360 VR recording, with each offering distinct benefits and factors to consider. Consumer cameras, such as those manufactured by GoPro and Insta360, can capture monoscope (2D) 360° footage and are commonly employed as action cameras. These cameras capture a comprehensive view of the entire scene from all directions using multiple overlapping fisheye lenses.

Conversely, professional 360 cameras, which are pricier, typically feature a greater number of lenses and can capture stereoscopic (3D) 360 footage. Single-lens 360 cameras capture the entirety of a scene, as their name indicates, through one spherical lens. They are user-friendly and perfect for convenient mobile filming. Nevertheless, multi-lens systems often exhibit superior image quality in comparison to single-lens systems (Ezell, 2021). Multi-lens cameras employ many lenses to capture the environment from various perspectives, which are subsequently merged to provide a cohesive 360° visual output. Such cameras provide superior image clarity and resolution, while they necessitate more intricate post-production procedures (Ezell, 2021). Custom rigs enable the arrangement of many conventional cameras in a spherical layout. This configuration also provides premium image quality and extensive modification options, but it is the most intricate and costly choice (Mantello, 2020). The selection of an appropriate camera for VR cinematography depends on the VR training material's specifications.

Novices may find it advantageous to begin their photography journey with a prosumer camera that has a reputable standing, such as the Nikon KeyMission or Garmin Virb (Haga, 2019). As an individual acquires additional expertise and encounters increasingly intricate demands, they can transition to cameras designed for professional use. Aside from the camera, supplementary equipment is required for a VR shoot. To ensure camera stability and maintain the appropriate eye level, it is imperative to utilize a tripod or monopod which the cameras may or may not be programmed to omit from the footage. Additionally, the inclusion of microphones is essential for capturing spatial or ambisonics audio during the production of 360° footage (VRdirect, 2021). The production of this OPOTA series was overseen by Hotbed Media with Eric Vaucelich and Jordan Herron managing the audio.


Figure 2. Police Officers Arriving in Car (left) & Moving Inside a House (right)
(Photo credits: Loriene Perera, 2023)

As with scenario exploration and scriptwriting, filming has to be preceded by lengthy research and experimentation. A crew composed of Ohio University students and faculty conducted multiple experiments to determine the optimal camera and microphones placement for every scene in the series. The goal is to have clear numerical instructions on where the equipment should be placed with relevance to the particularity of the scenario. The environment and the characters are dynamic, meaning they can change and move during the scene. For example, Figure 2 shows characters arriving in a car, walking up to a house, and moving inside the residence. The objective is to maintain visually and audibly proper footage at all times. While a cameraman can move the camera freely in a traditional 2D shoot, VR cameras are generally fixated during 3D shoots because unstable 360° footage often incurs an unpleasant viewing experience with possible motion sickness. Filming experiments can also take into consideration postproduction plans such as scene transitions. Skipping the research phase and leaving things up to improvisation on the day of the shoot can result in unsatisfactory footage, and it can increase production costs through longer filming sessions and potential reshoots.

**Postproduction: Editing, Transitions, and Graphic Overlays**

The final crucial step in developing impactful VR training material is editing, including the implementation of transitions and graphic overlays. Transitions in VR are not only decorative features; they have a vital function in preserving the coherence and the smoothness of the training material. Transitions in VR necessitate knowledgeable vision and understanding to prevent discomfort and disorientation. Unlike conventional video editing where there is an extensive list of accessible template transitions ready for use with relatively little to no necessary customization, there are limited available resources for VR editing. Often, editors are forced to either use commonly employed techniques such as cross-fades, wipes, and teleportation to seamlessly transition learners from one scene to another in 360° training material (Hussein & Nätterdal, 2015), or to innovate transitions for every project. However, the choice of the transition and the manner of its application are made complicated by the nature of the VR footage and the uniqueness of each scenario. Once again, research and experimentation resurface as requisites. For example, Figure 3 below showcases an experiment conducted by Ohio University students to determine the best transition for a chase scene which extends over two different locations.

Figure 3. Strip of frames from a transition experiment

Graphic overlays in VR training content enhance the immersive experience by offering more information or guidance (Williams et al., 2021). These can encompass textual instructions, data visualizations, or interactive components. To optimize the learning experience in VR, it is crucial to seamlessly include such graphics in the VR scene, hence boosting the immersion without causing any disruptions (Rupp et al., 2016). Postproduction editing in VR necessitates the use of specific software tools. Adobe Premiere Pro is commonly utilized for video

editing and implementing transitions, whilst Unity is a widely favored option for developing and incorporating visual overlays. In "Virtual Series I: Reality of Policing", several versions of some episodes are accessible for training. For example, episode 4 entitled "Pink Slip Issued on Runway Drive" is available in an original version where the audience can hear Maddy's hallucinations of her imaginary children and deceased husband (Williams & Herron, 2024), a second version where the hallucinations are removed, in addition to a third version also without hallucination but with added graphic clues that aim to help police officers read the room by identifying locations of potential weapons, locations of the mental health patient's medications, and important connections to their family (figure 4, left). Besides presenting information on the environment, graphic overlays can describe characters and events. For example, in episode 2 "Jumper on High Plains Bridge", there are graphics indicating both the techniques used by officers such as mirroring and emphasizing as well as the emotional state of the domestic violence victim such as anger, guilt, and despair (figure 4, right).


Figure 4. Examples of Graphic Overlays from Episode 2 (right) & Episode 4 (left)

Aside from transitions and visual overlays, the following essential postproduction techniques play a significant role in VR content creation:

- Spatial audio editing: Spatial audio is an essential element of VR that enhances the feeling of being present and fully engaged. It entails modifying audio to align with the spatial correlation of the video (Meta Quest for Creators, 2022c.; VR and 360 Video Production, 2020).
- Stitching: This refers to the procedure of merging many images or movies captured by various cameras to create a unified 360-degree video. This technology is crucial for producing immersive VR experiences (VR and 360 Video Production, 2020).
- Color correction and grading: This process entails making precise adjustments to the colors and tones in your VR footage to achieve uniformity among diverse scenes and increase visual attractiveness (VR and 360 Video Production, 2020).
- Visual effects (VFX): These can augment the VR experience by incorporating aspects that were not originally captured during filming. One possible enhancement is the use of 3D models, animations, or other visual effects (Meta Quest for Creators, 2022b).

- Rig removal: In 360-degree recordings, the camera rig, which is the apparatus that holds the camera, is frequently visible in the recorded footage. Rig removal procedures are employed to eliminate these aspects and enhance the viewer's perception of being present (Meta Quest for Creators, 2022c.; VR and 360 Video Production, 2020).
- Optimization: VR material can require a significant amount of computing resources. Optimization methods are employed in postproduction to guarantee seamless playback of the information across different devices (VR and 360 Video Production, 2020).

## Conclusion

### Challenges

These challenges stem from the immersive nature of VR and the need to capture a 360-degree view of the environment. Here are eight key challenges in pre-production, production, and post-production:

1. Complex Camera Setups: VR cameras typically consist of multiple lenses to capture a panoramic view. Ensuring that all lenses are synchronized and properly calibrated is essential. Placing multiple cameras while keeping them hidden can also require intelligent planning and execution.
2. Immersive Audio: Capturing spatial audio that matches the 360-degree video is crucial for immersion. Audio sources must be positioned and mixed accurately to match the visuals, which pose a challenge during the shoot and in post-production.
3. Storytelling: Traditional video editing relies on framing and directing the viewer's attention, which is more challenging in VR where the viewer has control over where they look. Crafting a compelling narrative that guides the viewer's gaze in a subtle proper manner can be challenging especially for beginners in the field.
4. File Size and Playback: 360 VR videos can entail large file sizes due to their high-resolution and wide frames. File size is also dependent on the type of camera and the bitrate. This presents challenges in storage, streaming, and playback, as viewers need a powerful device and a fast stable internet connection, if streaming, to enjoy VR content seamlessly.
5. Editing Tools and Techniques: Standard video editing software may not be well-equipped to handle 360-degree footage. Editors often need specialized software and plugins designed for working with immersive content. Poorly edited videos can induce motion sickness in viewers. Ensuring smooth transitions, avoiding rapid camera movements, and minimizing distortion are critical for comfort. In addition, more exploration and experimentation are needed in editing and creating transition effects.
6. Interactivity: VR experiences can be made interactive, which adds complexity to almost every stage of the content creation process. Interactivity can be realized through branching storylines, user-triggered events (such as moving or looking at a specific spot), or interactive elements (such as buttons or tools). Furthermore, similar content necessitates a game engine for execution instead of a regular video player.
7. Testing and Feedback: Since VR is a new medium, there is a need for extensive testing and user feedback to fine-tune the VR experience. This can be time-consuming and iterative.
8. Cost and Resources: Producing high-quality 360 VR content often requires specialized equipment and expertise, which can be expensive and may not be readily available to all content creators.

**Recommendations & Future Work**

As discussed, designing, and producing VR training material is a complicated process rigged with challenges that require creativity, expertise, and problem-solving skills to overcome. Therefore, our first recommendation is to put together a complementary team that includes Subject Matter Experts from various fields. In this OPOTA project, for example, there were contributing experts with backgrounds in instruction, psychology, safety, law, cinematography, screenwriting, editing, graphic design, and more.

Our second recommendation is to maintain a constant stream of communication between team members. Workflow is divided into three stages that are preproduction, production, and postproduction. In each stage, staff are divided into departments that are assigned specific tasks. Thus, the work environment in such projects is bound to be highly dynamic with lots of moving parts. Coordination among all staff is vital to keep the project going efficiently, and failing to provide necessary information in a timely manner can have severe consequences. Along the way, revisions will be made whether intentionally or unexpectedly. For example, things may not look or feel in VR as expected on paper or in theory. There can be uncontrolled factors such as the weather, failing equipment, and a set filled with unpredictable human beings. For instance, during our project, we had to change locations for one of the scenes, and we also learnt that actors like to improvise quite often. Consequently, we must stress the importance of flexibility, adaptability, and perseverance.

Our final recommendation has to do with the uniqueness of filming and producing in VR. Experimenting can be pivotal for the success of the project. Besides saving you time and money, which often go together, experiments were one of the many ways for the team to brainstorm and to prepare for the next steps. They also taught us several things such as camera movement does not go well with VR because it induces motion sickness, simple and fast transitions look better and more natural, and too many graphic overlays can make the VR experience less immersive and less realistic. So, our advice is to experiment generously with the different aspects of the project.

For future work, we see Mixed and Augmented Reality as the next evolution in the world of training. For our OPOTA project, this would have meant that police officers would see either whole scenarios or only certain actors or objects projected straight into the classroom, and they could collaboratively interact with these projections. They could also communicate or move on to a different activity more easily without having to take off their headsets repeatedly. This would require advanced headsets with pass through video capabilities such as Meta Quest 3 or Apple Vision Pro. Additionally, we want to explore using accessories that provide haptic feedback which would render the experience more immersive. Lastly, for more advanced projects, we anticipate interactive storytelling, where trainees can choose different paths affecting the outcome of the scenario (Zhang et al., 2019), to be a promising area for exploration in VR training. This could combine well with first-person narration and filming.

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