

Design Framework for VR Games in the Police Domain

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Abstract The escalation in the number of conflicts poses various implications and consequences to society, demanding a comprehensive understanding from a law enforcement perspective. The surge in conflicts introduces significant challenges related to public safety, necessitating adaptive strategies for both conflict and crime prevention and resolution. Accordingly, effective policing must adapt to the evolving dynamics, employing a nuanced approach that addresses the root causes of conflicts and enhances community resilience to avoid or mitigate them and their broader societal impact. A pivotal role in this direction is played by the ongoing technological advancements that facilitate actions like enhancement of situational awareness, analyzing patterns and anticipating potential hotspots and activities, facts that sustain both proactive and reactive measures. In particular, technological advancements in Virtual Reality (VR) present a valuable avenue for addressing policing challenges, especially in relation to conflict resolution, mitigation, and prevention. Building VR simulations for training purposes offers a controlled yet realistic environment for officers to practice e.g., de-escalation strategies and decision-making under stress. These gaming simulations provide a platform to expose officers to diverse scenarios, fostering adaptability, encouraging communication and collaboration, and enhancing their ability to properly handle conflicts with precision and self-control. At the same time, VR systems can be developed for societal awareness and educational purposes, fostering better understanding and communication between law enforcement and the public. While a broad range of governmental, practitioner, and academic efforts exist aiming at building and incorporating VR solutions for various purposes in the police domain, specific areas that involve other societal forces and bystanders need more attention. It is then the aim of this article to capture existing design and evaluation principles as well as lessons learned from existing VR solutions in the police domain. This is done by proposing a design framework for responsible VR gaming solutions in the police domain following the Design Science Research methodology in a transdisciplinary approach.

Keywords: Police, Law Enforcement, Police Conflict, Police Bystander, Virtual Reality.

1. Introduction

“Science cannot resolve moral conflicts, but it can help to more accurately frame the debates about those conflicts.” (Heinz Pagels)

In recent years, law enforcement agencies worldwide have faced a notable surge in both the frequency and complexity of incidents requiring their intervention. Statistical evidence shows a concerning rise in conflict and crime rates, the emergence of new forms of criminal behavior, and the proliferation of sophisticated criminal networks. Moreover, the advent of cybercrime, terrorism, and transnational organized crime has introduced unprecedented challenges, necessitating law enforcement personnel to possess a diverse skill set and adaptability to dynamic operational environments (Interpol, 2022; DHS, 2023; DHS, 2024; CBS, 2024). In light of these evolving threats, there is a pressing need for law enforcement agencies to equip their Police Officers (POs) with advanced training methodologies that adequately prepare them to navigate complex scenarios in an effective and adaptive manner. Virtual Reality (VR) technology emerges as a promising solution, offering immersive and realistic simulations that provide POs the opportunity to build their decision-making skills, enhance situational awareness, and cultivate the expertise required to mitigate multifaceted challenges safely, efficiently, and responsibly while being prepared to deal with the implications and consequences of (their) actions in a proper and accountable manner (Cao et al., 2023; Fard & Maathuis, 2021; Marker et al., 2020). At the same time, this approach allows POs to simulate high-stress, low-frequency incidents that are crucial for training but challenging to replicate in real-life scenarios, fact that enhances the preparedness for rare, but critical incidents (All, Castellar & Van Looy, 2021). Nevertheless, given the fact that limited research exists in relation to building such solutions in a systematic way, the objective of this research is to capture research areas that have benefited from the development of VR solutions in the Police domain and subsequently extract design requirements for building responsible VR gaming solutions tailored to the Police domain. To achieve this objective, two research questions (RQ) are posed:

- **RQ 1:** What are the topics tackled in existing VR solutions proposed in the Police domain?
- **RQ 2:** What are the design requirements and principles that could be of use for developing responsible VR solutions in the Police domain?

To address these questions, a systematic literature review is conducted following the methodology outlined by Denyer and Tranfield (2009). In this way, this research provides actionable insights for the development of future responsible VR gaming solutions tailored to law enforcement contexts, in particular, to the Police domain. By capturing design requirements and principles derived from existing VR solutions and synthesizing them into practical recommendations, this study offers guidance for the construction of responsible VR training platforms for POs. Such systems can potentially revolutionize law enforcement training by providing immersive and realistic scenarios that enhance decision-making skills, de-escalation techniques, and cultural competency, ultimately improving officer preparedness and community safety. Moreover, by adhering to principles outlined in methodologies like PRISMA, this research ensures methodological rigor and credibility, enhancing its practical relevance and potential impact on law enforcement training practices. At the same time, this research contributes to synthesizing and consolidating dispersed knowledge in the field, thereby enhancing the scholarly understanding of VR's applicability in police training and operations.

The remainder of this article is structured as follows. Section 2 discussed the methodological approach taken to achieve the aim of this research. Section 3 presents application areas and topics tackled when building VR solutions in the Police domain. Section 4 captures and structures design principles and requirements for building responsible VR solutions in the Police domain. Section 5 discusses concluding remarks and future research perspectives.

2. Research Methodology

This research aims to identify existing areas of research that benefitted of the development of VR gaming solutions and from there to capture design requirements for building future responsible VR gaming solutions in the Police domain. To this end, the following research questions are defined:

- **RQ 1:** What are the topics tackled in existing VR solutions proposed in the Police domain?
- **RQ 2:** What are the design requirements and principles that could be of use for developing responsible VR solutions in the Police domain?

To provide answers to these questions, a systematic literature review is conducted as delineated by Denyer and Tranfield (2009), which involves several essential steps. These include defining precise objectives, identifying relevant research studies, selecting relevant literature, conducting an in-depth analysis and synthesis of the findings, and presenting the results obtained. Following the principles outlined in the PRISMA methodology, data collection is executed utilizing the PRISMA 2020's stage flow diagram to ensure meticulous collection, screening, and analysis of data (Page et al., 2021).

In the realm of developing VR games for law enforcement training, systematic literature reviews play a crucial role in consolidating and summarizing pertinent evidence accurately and reliably. This facilitates the collection of valuable knowledge and empirical data that adheres to predefined criteria, empowering researchers to effectively address pivotal questions and derive informed insights regarding the efficacy of VR training in the police domain. The PRISMA methodology's effectiveness has been showcased across various fields, highlighting its significance in guiding efforts to enhance law enforcement training through VR technologies and equipping officers with the skills to navigate complex scenarios effectively and safely. To this end, the following research activities are taken as part of this process as illustrated in Figure 1 and further explained:

Activity 1 - Identification of studies: In this activity, studies have been selected based on combinations of keywords like *VR*, *virtual reality*, *law enforcement*, *Police*, *policing*, *criminal justice*, *police conflict*, and *police bystander*. In this process only articles in English are considered and are searched in the ACM, IEEE Digital Library, Web of Science, Wiley, and the first ten pages from Google Scholar. The timeline was considered between 01.01.2025 and 31.12.2023. Accordingly, the initial results contain 1887 articles from which 76 were duplicates that have been directly removed.

Activity 2 - Screening of studies: During this activity, the studies underwent screening based on their abstract, title, and keywords, with criteria such as relevance to the topic and direct relevance to VR and Police domains applied for exclusion. As a result, a final set of 20 studies was identified for further review.

Activity 3 - Inclusion of relevant studies: In this activity, the final 20 research studies gathered underwent comprehensive reading and analysis, with their scope summarized in Table 1.

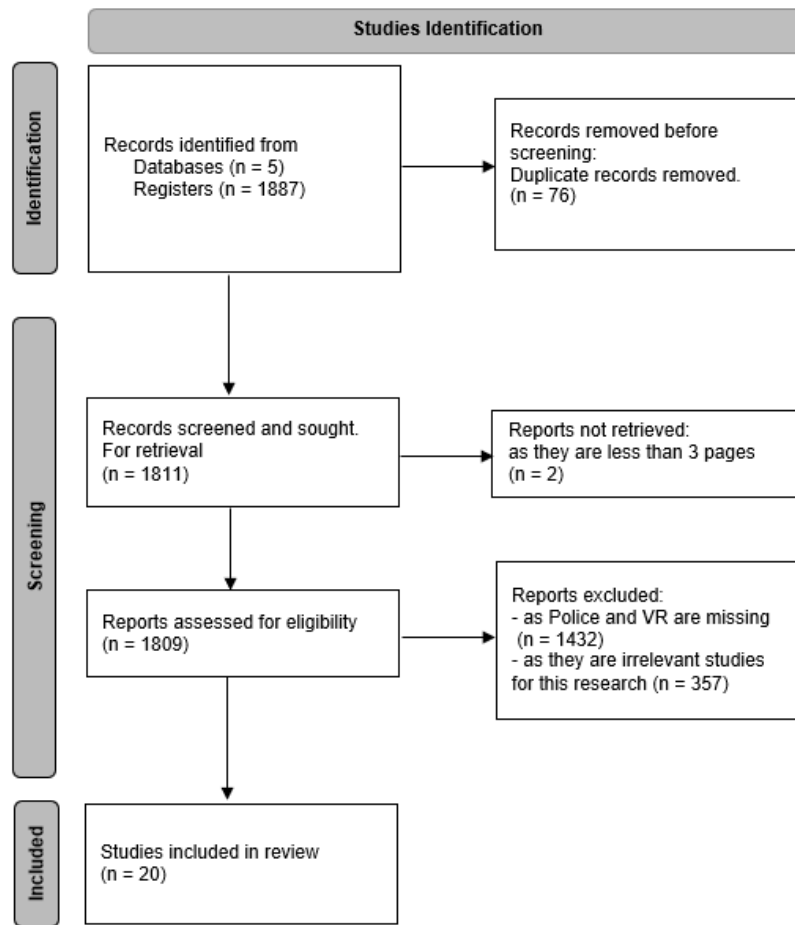


Figure 1: Research Methodology.

Table 1: Information about the studies selected.

No	Title Study	Year	Research Aim	Venue Type	Reference
1	Virtual Reality Training of Law Enforcement Officers in Predicting Terroristic Attacks Indicators	2022	To design a VR-based serious game for Police training for the identification of suspicious terrorist activities.	Conference	Soldatos et al., (2022)
2	Validating Virtual Reality as an Effective Training Medium in the Security Domain	2019	To assess the effectivity of a VR training for LEAs (Law Enforcement Agencies) and first responders, and compare the results in relation to conducting the same exercises without VR in live settings.	Conference	Saunders et al., (2019)
3	Trusted Virtual Reality Environment for Training Security Officers	2023	To build a VR-game for training LEAs and security professionals in the analysis and prediction of potentially terroristic activities.	Conference	Pantazidis et al., (2023)
4	Exploring VR Training for First Responders	2020	To explore VR training challenges and review four public safety VR scenarios.	Conference	Haskins et al., (2020)
5	The Impact of Virtual Reality in the Social Presence of a Virtual Agent	2020	To assess the impact that a social interaction with an Intelligent Virtual Agent has on subjects across different mediums with different	Conference	Guimarães et al., (2020)

No	Title Study	Year	Research Aim	Venue Type	Reference
			immersion levels.		
6	Virtual reality for law enforcement training: a demonstration and implication for dispatch priming	2022	To assess the impact of a VR-intervention in a case of dispatch priming.	Journal	Potts et al., (2022)
7	Virtual reality training for police officers: a comparison of training responses in VR and real-life training	2024	To assess VR SBT in VRT training of POs.	Journal	Kleygrewe et al., (2024)
8	Can a Virtual Reality Training Scenario Elicit Similar Stress Response as a Realistic Scenario-Based Training Scenario?	2024	To assess if a VR training scenarios would elicit a similar stress response as a realistic scenario-based training scenario.	Journal	Martaindale et al., (2024)
9	Deep-Breathing Biofeedback Trainability in a Virtual-Reality Action Game: A Single-Case Design Study with Police Trainers	2022	To assess response inhibition in police-decision making contexts.	Journal	Michela et al., (2022)
10	A Virtual Reality Embodiment Technique to Enhance Helping Behaviour of Police Toward a Victim of Police Racial Aggression	2019	To explore the effectiveness of VR embodiment techniques in reducing implicit racial bias among POs.	Journal	Kishore et al., (2019)
11	The Cycle of Violence: Understanding Individual Participation in Collective Violence	2015	To explore the role of group identity in individual participation in collective violence and the impact of such behaviour on group identification.	Journal	Litman & Paluck (2015)
12	Measuring presence and performance in a virtual reality police use of force training simulation prototype.	2019	To develop a VR training simulation designed to help POs learn and apply use of force policies effectively.	Conference	Garcia, Ware & Baker (2019)
13	Stress out: translating real-world stressors into audio-visual stress cues in VR for police training	2021	To develop and validate a VR training simulation for POs, focusing on improving decision-making in use of force scenarios.	Conference	Nguyen et al., (2021)
14	A concept of a training environment for police using VR game technology.	2018	To design a police training VR-tool for traffic control.	Conference	Caserman et al., (2018)
15	The potential of virtual reality for police training under stress: a SWOT analysis. In Interventions, training, and technologies for improved police well-being and performance	2021	To explore the potential of VR in enhancing police training, particularly in stress management, decision-making, and situational awareness under stress.	Journal	Voigt (2021)
16	Virtual training: Making reality work?	2015	To develop a Virtual Training Environment (VTE) for training police personnel in complex collaborative tasks, with a focus on interactions between police ground forces and helicopter crews.	Journal	Bertram, Moskaliuk & Cress (2015)
17	The desert of the unreal: Inequality in virtual and augmented reality.	2017	To investigate the potential of VR and AR technologies to enhance equality and reduce bias in various societal contexts, including job interviews, law enforcement training, and public privacy	Journal	Franks (2017)

No	Title Study	Year	Research Aim	Venue Type	Reference
			concerns.		
18	An Integrated emotional and psychological assessment for VR-based active shooter incident experiments	2021	To test the effectiveness of an active shooter VR experiment on emotional and physiological responses to evaluate the realism of the active shooter scenario for research or training purposes.	Journal	Awada et al., (2021)
19	A meta-analysis of virtual reality training programs	2021	To explore the effectiveness of VR training programs compared to traditional training methods across various professions, including police and military personnel.	Journal	Howard, Gutworth & Jacobs (2021)
20	A review on virtual reality skill training applications	2021	To evaluate the effectiveness of VR training platforms in enhancing high-level motor skills and ensuring accurate task performance in complex environments.	Journal	Xie et al., (2021)

3. Application Areas

Based on the research conducted, four distinct categories of research lines have emerged in the development and application of VR solutions within the Police domain. These categories encompass a broad spectrum of objectives, ranging from refining procedural skills to addressing counter-terrorism efforts, socio-ethical considerations, and psychological well-being within law enforcement practices. As VR technology continues to advance, these categories offer valuable insights into the diverse applications and potential impacts of immersive training methodologies for law enforcement personnel. Furthermore, each of these categories is discussed and its distribution is represented in Figure 2, as follows:

Category 1 - Procedural: This category delves into the operational protocols and training methodologies essential for law enforcement tasks. The studies within this category explore a range of procedural aspects, including the identification and handling of suspicious packages, traffic control procedures at checkpoints, the influence of dispatch information on response dynamics, techniques for effective traffic management, methods to enhance collaboration among emergency responders, and the assessment of VR training program effectiveness through robust evaluation methodologies (Saunders et al., 2019; Haskins et al., 2020; Potts et al., 2022; Caserman et al., 2018; Bertram, Moskaliuk & Cress, 2015; Garcia, Ware & Baker, 2019; Howard, Gutworth & Jacobs, 2021; Xie et al., 2021).

Category 2 - Terrorism: This category encompasses research aimed at understanding and combating terrorist activities. The studies within this domain discuss the development and utilization of VR-based serious games for training in counter-terrorism scenarios. They also delve into methodologies and technologies employed for the prediction and detection of terrorist activities, reflecting a comprehensive approach towards enhancing security measures and preparedness in the face of evolving threats (Soldatos et al., 2022; Pantazidis et al., 2023).

Category 3 - Socio-ethical: This category addresses critical social and ethical considerations within the Police domain by examining issues related to bias and social dynamics. The articles within this category probe into the complex issue of racial bias in policing, exploring interventions and strategies to mitigate its impact. Additionally, they delve into innovative approaches for reducing bias in law enforcement practices, reflecting a commitment to fostering equity and fairness in policing (Kishore et al., 2019; Franks, 2017).

Category 4 - Psychological: This category is centered on the psychological well-being and training of law enforcement personnel. The studies within this category explore training programs aimed at enhancing social skills among officers and assessing their responses to scenario-based training in virtual environments. They also delve into methodologies for evaluating stress responses and implementing biofeedback techniques to manage stress effectively. Moreover, this category investigates the psychological factors influencing individual participation in collective violence, along with the emotional and physiological responses of officers to simulated high-stress situations like active shooter incidents (Guimarães et al., 2020; Kleygrewe et al., 2024; Martaindale et al., 2024; Michela et al., 2022; Litman & Paluck, 2015; Nguyen et al., 2021; Voigt, 2021; Awada et al., 2021).

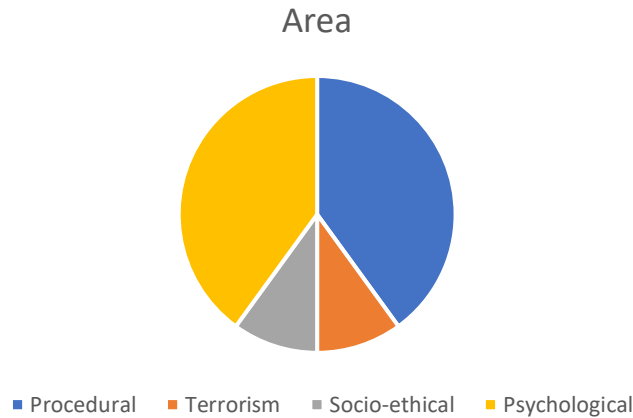


Figure 2: Application areas.

4. Design

Given the potential societal impact and ethical considerations surrounding the development and deployment of VR solutions for policing, the systematic collection and structuring of design requirements and principles are important. Such an approach ensures that future VR solutions in the police domain are developed and deployed responsibly in a human-centered approach (Maathuis, 2023). First and foremost, comprehensive requirements gathering enables the identification of specific operational needs, such as training scenarios, crime scene reconstruction, and immersive simulations for tactical decision-making. Structuring these requirements facilitates the alignment with ethical standards, legal frameworks, and community expectations, fostering transparency and accountability in VR utilization by law enforcement agencies. Moreover, incorporating principles of fairness, equity, and privacy into the design process safeguards against potential biases and abuses of power, promoting trust and legitimacy in VR-enabled policing practices. Thus, the meticulous delineation and adherence to design requirements and principles serve as indispensable safeguards, guiding the ethical and responsible evolution of VR technologies within the Police domain. To this end, six categories of design requirements are gathered and clustered given their purpose, as follows: scenario, hardware, education, data and AI, evaluation, and ethics and security. For each of these clusters, the design requirements are presented below:

Cluster 1: Scenario-based design requirements (Voigt, 2021; Xie et al., 2021; Saunders et al., 2019; Soldatos et al., 2022; Haskins et al., 2020; Bertram, Moskaliuk & Cress, 2015; Bertram, Moskaliuk & Cress, 2015; Kishore et al., 2019):

- The scenario needs to be representative, relevant, and accurate to real-world incidents, and aligned with Police goals and perspectives.
- The context of a scenario needs to be described in detail and needs to replicate real-world situations.
- The scenario needs to enhance user engagement and use VR headsets and peripheral in an effective way.
- The scenario needs to consider (some) degrees of freedom so that the experience is enhanced and supports the adaptation to multiple situations as in the real-world.
- The scenario needs to present opportunities that give an overall safe and controlled experience.
- In comprehensive training, consider multi-player role-based gameplay and collect relevant information.
- If possible, allows users to experience multiple (user) perspectives.
- If successful and desired for training purposes, the scenario needs to respect Police training methodologies and practices.

Cluster 2: Hardware-based design requirements (Howard, Gutworth & Jacobs, 2021; Kishore et al., 2021):

- Choose appropriate hardware based on project requirements and target audience.
- User high-quality VR hardware for an immersive experience.
- Consider modifications of settings to accommodate physical variations of participants.
- Align real movements with the virtual avatar's actions.
- Incorporate plugins for seamless integration of tracking information.

Cluster 3: Training design requirements (Potts et al., 2022; Voigt, 2021; Haskins et al., 2020):

- Consider an adaptable approach in order to tailor the solution to user's skill level and experience to promote cognitive engagement.
- Consider repetitive and iterative steps, adjust to various difficulty levels, and conduct after-action review.
- Incorporate constructive feedback mechanisms to allow users to explore multiple options and coping strategies.
- Incorporate immediate and later/post-simulation feedback mechanisms to enhance knowledge retention and transfer.

Cluster 4: Data and AI design requirements (Pantazidis et al., 2023; Soldatos et al., 2022; Caserman et al., 2018):

- Implement data governance, security, privacy, and quality mechanisms for both contextual and inside game data, e.g., use safe decentralized solutions like blockchain.
- Ensure data consistency and accessibility for demonstration, evaluation, and training purposes.
- Consider the collection and analysis of full-body tracking data and virtual agents' data to enhance immersion and realism and capture relevant information.

Cluster 5: Ethics design requirements (Voigt, 2021; Litman & Paluck, 2015; Franks, 2017; Guimarães et al., 2020; Awada et al., 2021):

- Ensure ethical, security, and privacy mechanisms since the design process.
- Ensure the physical and psychological safety of the participants involved.
- Consider safety measures when dealing with violence or harm and reduce such content when possible.
- Address potential ethical concerns and prioritize respect, consent, and empathy in the design of the solution.
- Assure the diversity, equity, and inclusivity of individuals since the design process and during simulation/training.
- Ensure that users and corresponding agents can dynamically respond to actions and maintain an ethical conduit during execution.

Cluster 6: Evaluation design requirements (Soldatos et al., 2022; Haskins et al., 2020; Potts et al., 2022; Garcia, Ware & Baker, 2019):

- Make evaluation information available to users after playing/engaging with the game.
- When possible, provide the opportunity to users to adjust or provide suggestions to the design of the scenario or solution in order to capture different perspectives and improve the game/solution considered.
- Implement a transparent scoring mechanism and provide tailored feedback based on it.

These clusters provide a comprehensive guide on design requirements and principles to be considered when building future responsible VR solutions tailored to the needs of Police goals and perspectives, considering technological, ethical, and psychological aspects.

5. Conclusions

In the law enforcement domain, numerous challenges persist, ranging from the evolving tactics of terrorism to the complexities of decision-making in high-pressure situations. Traditional training methods have limitations in adequately preparing POs for the diverse and dynamic scenarios they may encounter. Nevertheless, recent VR advancements offer promising solutions to address these challenges by building effective simulation solutions that mirror real-world situations and settings and allow POs to rehearse various enforcement skills, deployment strategies, and critical decision-making models in virtual but realistic scenarios, without endangering themselves or the public (Saunders et al., 2019; Pantazidis et al., 2023; Potts et al., 2022). Additionally, VR gaming solutions offer advantages such as flexibility in scenario creation, detailed after-action reviews, and the ability to train officers independently of specific physical locations (Kleygrewe et al., 2024). This allows the integration of VR solutions into Police training to be perceived as a significant step towards addressing the challenges faced by law enforcement and ensuring that officers are better equipped to handle the complexities of their duties in various contexts and situations.

Hence, to advance the development of responsible VR solutions for the Police domain in complex scenarios and

situations such as Police-bystander conflict, it is important to systematically capture and analyze the design requirements of existing solutions. Such an approach ensures that future VR training solutions effectively address the multifaceted challenges faced by POs while upholding ethical standards and promoting community safety. By studying the design elements of current VR solutions, including their scenario development methodologies and interaction mechanics, engineers can gain valuable insights into what works well and what needs improvement (Dau et al., 2023). This iterative process allows for the refinement of VR training environments to better simulate the complexities of real-world policing, including the unpredictable dynamics of bystander interactions. Incorporating these insights into the design process enables the creation of immersive VR solutions that not only enhance POs' decision-making skills and situational awareness but also foster empathy, cultural competency, and digital responsibility (Maathuis, 2022; Rojas-Sánchez, Palos-Sánchez & Folgado-Fernández, 2023), and de-escalation techniques when dealing with bystander conflicts. This represents the future path that this research embarks on. Other possible future research avenues could consider the integration of a data-drive approach and incorporating LLMs (Large Language Models) and/or a multimodal modal for building and simulating a large set of scenarios that analyze the interaction, relations, and dynamics involved in the process of conflict de-escalation and resolution considering various sources of stimuli. At the same time, another research line could deal with analyzing and modelling diverse ethical, social, and legal dimensions that play an important role when developing, deploying, and using VR applications in police conflict training. Conclusively, by grounding future VR solutions in evidence-based design principles and best practices, this article aims to contribute positively to law enforcement training while minimizing potential risks and ethical concerns.

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