The Efficacy of Virtual Reality Training in the Military

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Abstract

This research paper examines the effectiveness of virtual reality (VR) training within the military in collaboration with the Rhode Island Air National Guard. It explores the advantages and disadvantages of VR training compared to traditional training methods, emphasizing situational awareness and decision-making, scenario simulation, engagement and retention, and cost reduction. By analyzing existing research, industry applications, and firsthand accounts, this paper provides insights into the efficacy of VR training and how it enhances training outcomes for military personnel. For example, VR-based instruction boosts engagement and knowledge retention. In one study, trainees retained about 75% of information learned from a VR lesson compared to 5% for reading and 10% for classroom lectures (Rea, 2024). Additionally, real-world scenarios can be realistically and safely simulated to improve situational awareness and adaptability to new situations where mistakes can be costly, such as aircraft maintenance or fire-fights (Nolen, 2022). However, challenges and limitations arise, such as the cost of initial implementation, motion sickness, and instructor adaptation needs (Velichko, 2021). This paper employs a mixed-method approach by analyzing empirical research and interviews with Air National Guard personnel, evaluating whether VR can effectively supplement or replace traditional military training.

Introduction

VR is a technology that simulates a three-dimensional environment that can be interacted with via devices like head-mounted displays. This technology immerses users in a virtual space, allowing them to experience scenarios that mimic real-world conditions without the associated

risks. In the military context, VR training can be used to mitigate risks and costs associated with training and recruitment. Currently, VR training is revolutionizing military readiness. In a survey of over 400 U.S. military trainers and procurement specialists, 81% said that Extended Reality (XR, an umbrella term encompassing virtual reality, augmented reality, and mixed reality) training increases confidence and cultivates muscle memory (Vive Team, 2023). The military's current VR implementations allow for the training of hundreds of personnel per year, enhancing situational awareness and reducing training time (Roza, 2024). This scalability is valuable in large organizations like the military, where efficiently training large numbers of individuals poses a constant challenge. Overall, this research assesses VR training's effectiveness compared to traditional methods, considering quantitative metrics like decision-making, skill retention, and cost efficiency, alongside firsthand accounts from Rhode Island Air National Guard personnel. The primary goal is to determine whether VR can serve as a supplement or even a replacement for conventional training methods.

Background and Problem Statement

The military has long relied on traditional methods (drills, weapons training, field training) to prepare its personnel to be effective soldiers on the battlefield. While still effective, these methods are becoming obsolete for several reasons, such as standardization, lack of adaptability to modern threats, physical and psychological strain, and resistance to change. The military prioritizes a one-size-fits-all solution in its training, which can hinder individual progress, especially in ROTC programs. (For instance, ROTC cadets often undergo standardized drills that fail to address certain leadership or tactical development needs) (Roysden, 2024). This

rigidity can leave some trainees feeling underprepared for the complex and extensive demands of leadership or specialized tasks.

Moreover, traditional training methods struggle to keep up with the rapid development of new technologies, sometimes failing to simulate modern battlefield conditions effectively (Ahmed, 2024). The rise of unmanned aerial vehicles and other advanced systems has transformed warfare, requiring soldiers to adapt to situations that traditional training methods may not adequately replicate. High-intensity training situations can also cause physical and psychological stress, leading to decreased retention and performance among personnel. (Lyndall, 2020) For instance, prolonged live-fire exercises or simulated combat drills can exhaust trainees to the point of hindering their ability to absorb lessons. In addition, resistance to change among military institutions also acts as an obstacle to discovering better training methods. Many senior leaders, accustomed to established protocols, may be skeptical of new technologies like VR and fear they may disrupt the usual live-drill playbook (Velichko, 2021).

VR's military implementation effectively addresses these challenges, but not without some caveats. For instance, VR offers personalized training, ensuring better individual progress over the long term (Dalladaku, 2024). VR can tailor scenarios to match a trainee's skill level, allowing inexperienced personnel to build foundational skills while challenging veterans with more complex simulations. However, VR is not without its limitations. Skeptics point out specific problems that may arise: Can VR training really transfer to real-world skills, or will personnel struggle in the real world despite the virtual exposure? Will high upfront costs limit VR's scalability in the military? How will traditional instructors adapt to an entirely new way of

training? These questions underscore the importance of evaluating VR's usefulness in military applications, and this study examines how VR can address traditional training limitations (minimal knowledge retention, expensive and infrequent exercises) and concerns surrounding VR's military integration. This research aims to provide a comprehensive view of VR's potential role in future military training by assessing its advantages and disadvantages in the military training context.

Methodology

This study follows a mixed-method approach, evaluating previous research on VR in the military and firsthand accounts of personnel from the Rhode Island Air National Guard. The analysis included several studies from military and government sources, selected based on their focus on VR training outcomes and military relevance. All sources were chosen based on their credibility and applicability to the military context. Among these, Velichko (2023) and Harris et al. (2022) offer valuable insights that shape this paper's framework. While Velichko's article highlights cost concerns, Harris et al.'s data provides stronger evidence concerning decision-making. Both influence this study, but the latter carries more weight. Quantitative metrics like skill retention rates, cost figures, course duration, and performance were extracted to allow for an objective comparison. Data was gathered on time savings in training (Roza, 2024) and the cost benefits of VR training versus traditional training (Lyndall, 2020). These metrics ensure a measurable basis for comparing VR's efficiency to conventional methods.

Qualitative data were collected primarily through interviews with three Rhode Island Air National Guard airmen who have operated VR systems, featuring open-ended questions about

their experiences with traditional and VR training, perceived benefits, and limitations. These interviews offered raw insight into human perspectives on VR-military integration, revealing how VR feels in practice compared to the theoretical benefits highlighted in the literature. The airmen's answers included reflections on specific training scenarios, such as aircraft maintenance simulations and combat drills, providing a more in-depth understanding of VR's impact. Through the combination of quantitative analysis and qualitative feedback, this mixed-method approach ensures a balanced evaluation of VR's efficacy in military training.

Literature Review

After thorough research and review of previous studies and literature, it is clear that VR training benefits the military in four main areas: situational awareness and decision-making, scenario simulation, engagement and retention, and cost reduction. VR can enhance judgment under stress, and a UK study showed that individual performance in VR simulations of shoot/don't shoot scenarios closely matched live-fire performance (Harris et al., 2023). This demonstrates that VR training can instill practical decision-making skills in a safer and more personalized environment. The ability to repeatedly practice high-risk situations, like distinguishing between friendly and unfriendly during combat, all without real-world consequences, is significantly advantageous. Similarly, Air Force pilot training experiments that used VR found that student pilots could reach required proficiency in maneuvers and emergency procedures in less time than with traditional instruction (Nolen, 2022). ANG security forces use VR to simulate active shooter scenarios, with trainees noting the simulation's realism and reduction in live-fire travel costs (Nolen, 2022). VR simulations are highly effective in

simulating scenarios that are either too difficult or too costly to replicate physically, like active shooter scenarios and flight simulations. Flight simulators are notably effective, especially when real flight training isn't available, like in poor weather conditions or when the aircraft are undergoing maintenance. These scenarios increase situational awareness with lifelike intensity (including the chaotic visuals and sounds), allowing for safe replication of battlefield environments (Nolen, 2022). For instance, VR can simulate the noise of gunfire, the blur of smoke, and the urgency of an ambush, all within a safe and controlled setting that can be easily replicated if necessary.

Regarding engagement and skill retention, research shows a 75% retention with VR versus 5% for classroom instruction or 10% for reading (Rea, 2024). Rea's 75% retention statistic is significant, but it is unclear whether it holds under combat pressure. Regardless, it is more effective than classroom instruction or reading, where pressure is not a factor. This dramatic difference originates from VR's hands-on nature, which engages multiple senses and reinforces learning through repetitive action. Furthermore, Army VR simulations can improve soldier preparedness; ANG Airmen at Ellsworth Air Force Base using VR medical simulators retain trauma care steps better than they would from a textbook due to the realism and repetition, with 84% of reporting significant medical skill improvement (Maher, 2025). In these simulations, airmen practice procedures like applying tourniquets or stabilizing fractures, gaining muscle memory that theoretical instruction cannot provide. VR training is valuable in specific situations like these, where actual practice might not be possible or practical.

With traditional training comes many expenses, and VR can help to enhance its cost-effectiveness. For example, standard training procedures may require travel, ammunition, fuel, etc., depending on the task (Lyndall, 2020). A single live-fire exercise might involve transporting personnel to a range, expending thousands of rounds of ammunition, and maintaining equipment, all of which add up quickly. VR can simulate scenarios without the necessary resources for traditional training. VR environments significantly reduce operational costs by preventing expensive mistakes, like misconfiguring an aircraft engine, where blunders can cost millions of dollars (Roza, 2024). Additionally, VR offers cost-effective opportunities for repeated practice without consuming valuable physical resources or causing damage. VR helps reduce costs to such an extent that the U.S. Army invested $2.7-3 billion into it in 2019, with that figure being expected to reach upwards of $19 billion by 2027. (Lyndall, 2020) This investment reflects confidence in VR's long-term savings, eliminating routine expenses like fuel and ammo while allowing for replicable, adaptable training modules (Moeger, 2024).

Interviews

Data were collected from speaking with three Rhode Island Air National Guard airmen, each for 30 minutes, on February 26, 2025, at their North Kingstown base. The interviews consisted of open-ended questions like, "How do you compare VR training to traditional methods?" and "How effectively does VR training prepare personnel for real-world performance?" Notes were taken on specific themes like "Cost Savings," "Realism Limits," and "Training Flow." To begin, one airman explained, "VR modules are a game-changer for initial training. We can practice welding, painting, and corrosion prevention without the risks of

carcinogens or wasting materials. It's efficient and cuts down on time." Another mentioned flight simulators allowing for pilot training when physical flights aren't an option, stating, "Flight simulators let us train when real flights aren't possible, like in bad weather." A third airman shared, "Medical VR could be a game-changer. Simulating Tactical Casualty Combat Care would let medics practice life-saving skills in a controlled environment. It's a great area for VR implementation."

All airmen emphasized VR's cost-saving potential, with one bringing up the example of an aircraft engine. These engines cost millions of dollars, and mistakes can be devastating and resource-intensive. If a trainee makes a mistake on a VR program, there is no financial risk whatsoever. When asked how VR is currently integrated into the Rhode Island Air National Guard, they answered that it often involves modules used extensively during initial training, typically beginning with classroom-based theoretical training (textbooks and lectures), followed by hands-on practice and lab sessions. The progression from classroom study to practical labs to hands-on training is continuous and self-paced, allowing personnel to maintain preparedness for deployment. They highlighted that this structure facilitates skill-building in a controlled environment before application in high-stakes environments.

However, the airmen also noted limitations. They stressed that VR struggles to mimic real-world stress, emphasizing that it cannot entirely replace traditional training. OPSEC clearances also slow the scaling of VR training, a criticism that Velichko also brings up. These discussions offered a raw, practical perspective of how VR integration can alter the military training landscape.

Challenges and Limitations

Despite all of the positives associated with it, VR isn't without its limitations. Potential downsides include high initial investments, instructor adaptation, individual reactions to VR, and the gap between virtual training and real-world experience. To begin, VR can have high upfront installation costs due to all of the hardware and software requirements (Velichko, 2021). A complete VR setup might include headsets, motion trackers, high-powered computers, and custom software, totaling millions for large-scale adoption. In addition, maintenance of the systems and potential software fees may lead to long-term costs. The hardware that VR requires to work effectively can be unreliable and malfunction in certain cases (for example, camera tracking issues) (Lyndall, 2020). This would require specialized personnel on-site who can tend to the systems in the event of a technical failure. Maintenance also includes calibration of devices and hardware/software upkeep. These ongoing needs could strain military budgets, specifically for smaller units. One solution could involve phased implementation or increased leverage of government funding, as seen in the Army's $2.4 billion investment (Moeger, 2024). Gradual adoption allows costs to be spread out over time, while federal support can help to account for initial expenses.

VR training, while effective, also requires adaptation from the instructors who will utilize it. Senior instructors and commanders may distrust VR training compared to the traditional live-drill playbook (Velichko, 2021). For instance, an instructor with decades of experience leading live drills may doubt a virtual simulation's effectiveness in preparing soldiers for the unpredictability of combat. Over time, demonstrations, success stories, and policy integration

will be required to gain acceptance. Showcasing VR's success in distinct cases, like improved pilot performance, has the potential to shift attitudes among both instructors and trainees (Nolen, 2022). This research aims to aid in VR's implementation while offering objective information on its effectiveness in the military training context, potentially helping to shift attitudes in these personnel.

VR can also cause motion sickness (cybersickness) and physical strain in some trainees, particularly in individuals with minimal VR experience (Harris et al., 2023). Symptoms such as nausea, dizziness, and eye strain are commonplace among inexperienced VR users and can disrupt training sessions, reducing their effectiveness. Integrating higher-quality headsets, frame rate improvements, and gradual exposure helps to mitigate this. Also, shortening training sessions to between twenty and thirty minutes will help to reduce the physical strain associated with prolonged VR use. Research suggests shorter, more frequent sessions can preserve engagement potential while minimizing discomfort and negative symptoms, allowing trainees to build tolerance over time (Harris et al., 2023).

Perhaps the most considerable limitation of VR is the inability to replicate real-world stress and risks (Dalladaku, 2024). The lack of authentic pressure and risk may lead to trainees taking unrealistic risks because there are no real-world consequences. A trainee may charge into a virtual firefight without hesitation, knowing they can reset the simulation if necessary, which may be a dangerous mindset to have in combat. Therefore, over-reliance on VR can be detrimental and lead to a lack of real-world experience and risk management. To mitigate this, a hybrid training approach (i.e., traditional, real-world training methods in conjunction with

occasional VR simulations) should be established to ensure a well-rounded training environment (Lyndall, 2020). This hybrid model allows VR to supplement, not replace, live training's lessons, ultimately balancing technological innovation with practical experience.

Conclusion and Recommendations

In conclusion, VR can significantly enhance military training and preparedness and offer efficient instruction and cost-effectiveness. It addresses some of the biggest challenges in conventional training, including knowledge/skill retention, adaptability, and inconvenient/insufficient conditions for training (Nolen, 2022). The mixed-method approach that includes prior studies and interviews with airmen supports VR effectiveness in realism and engagement, while offering insight into both quantitative and qualitative perspectives on VR's impact in the military. While the benefits of VR implementation are vast, the challenges and limitations are valid considerations that should not be overlooked. VR's integration requires a large budget because of the high upfront costs associated with all the prerequisite technologies (Velichko, 2021). Senior instructors and leaders also require acclimation to these technologies, and personnel capable of handling technical errors with the VR system will be necessary (Velichko, 2021). The largest obstacle to the mainstream acceptance of VR as an effective military training method may be real-world transferability, because real-world stress cannot be perfectly simulated in a virtual environment (Dalladaku, 2024). The best approach for implementing VR would be integrating it and traditional training methods into a hybrid training protocol (Lyndall, 2020). This combination allows for VR to drill niche scenarios, while live runs teach composure amidst the chaos of a real fight (Lyndall, 2020). Not only does this

potential solution offer better technical skill-building than either VR or conventional training alone, but it also ensures real-world experience and resilience. For implementation suggestions, starting with pilot programs in specific areas like urban combat, medevac, and vehicle/aircraft maintenance would be an effective introduction. Data on these programs should be collected to improve how VR is used in each area, and current instructors should be trained on how to use VR for both themselves and their personnel. The data collection will allow for the technology to be improved over time, both hardware and software, leading to better training outcomes. With refinement and investment, VR has the potential to transform military training as we know it while maintaining the strengths of conventional methods.

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