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An Evaluation of the "Police Response to Uncrewed Aircraft Systems Operations" Online Training Program

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This study evaluates the impact of the "Police Response to Uncrewed Aircraft Systems Operations" online training program of officers from the Daytona Beach Police Department (DBPD). By measuring the effectiveness of the training through pretest and posttest assessments and considering variables such as educational background, length of service, and rank, this research underscores the training's potential to enhance UAS response capabilities. Employing a self-selection sampling method, the study engaged 82 voluntary participants from the DBPD, revealing significant improvement across all groups in UAS knowledge and confidence levels. Despite limitations, these findings offer compelling evidence of the training's efficacy and advocate for continuous education to strengthen law enforcement's readiness and public safety preparedness in the face of evolving technological challenges. Future investigations should delve into long-term effects and underlying factors to bolster the robustness of these results.

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Introduction

Daily uncrewed aircraft systems (UAS) flights in the United States are expected to reach 1 million by 2035 (NBC, 2015). UAS is an emerging technology with low entry barriers for individuals who want to fly UAS in the National Airspace System (NAS). Anyone can purchase a UAS online or in person in a store without any required documentation from the Federal Aviation Administration (FAA) or the US Government. To fly a UAS in the NAS, individuals must follow specific federal and state regulations based on the purpose of the flight and the airspace in which the flight will be conducted to ensure safe operations (FAA, 2023b). UAS can be remotely piloted by an individual or autonomously programmed using computer software to follow global positioning system (GPS) coordinates. UAS comes in a variety of sizes and designs and can be modified to do specified tasks for dull, dirty, and dangerous jobs (Cerreta et al., 2022).

The growing prevalence of affordable small drones presents numerous challenges in effectively integrating Unmanned Aircraft Systems (UAS) operations into the national airspace system (Potana et al., 2023). So far, the FAA has released only limited information online regarding 15,644 "UAS Sighting Reports" from the United States, covering the period between 2014 and the conclusion of 2022 (Howard, 2023). The FAA continues to receive upwards of 100 such reports. There is a significant chance of UAS activity in the coming years, potentially leading to more safety incidents (Howard, 2023). Using airspace by unmanned aerial vehicles necessitates adjusting to a mounting array of legal regulations (Kubas, 2023). Operating Uncrewed Aircraft Systems (UAS) in proximity to airports and aircraft is not inherently unsafe or illegal. The FAA emphasizes that operating Unmanned Aircraft Systems (UAS) near aircraft, helicopters, and airports can potentially pose significant security and safety risks, among other issues if regulations are not adhered to diligently. There is a propensity for a collision between a crewed aircraft and a UAS near airports since they both fly at low altitudes, even though UAS are prohibited from flying in these critical areas (Pothana et al., 2023).
On July 21, 2022, according to the FAA, officials stopped incoming and outgoing flights at Ronald Reagan Washington National Airport for approximately 13 minutes after a UAS sighting was reported (Shepardson, 2022). The FAA reported that it quickly alerted law enforcement, and those operations had resumed, albeit with lingering delays. The perpetrator has not yet been located. The region surrounding Ronald Reagan Washington National Airport has the most stringent UAS restrictions in the United States (FAA, n.d.). Without specific FAA permission, flying a UAS within a 15-mile radius of the airport is illegal, a condition that applies to all of Washington, DC. Even with the limits, infractions go unpunished, perpetuating the critical issue (FAA, n.d.). The FAA relies on a voluntary compliance methodology for all UAS operators and those reporting the sightings (FAA, 2023b). Unauthorized operators may face severe financial penalties and criminal prosecution, including possible imprisonment (FAA, 2022a).

Police officers are required to handle calls for service ranging from delivering babies and bringing life into the world to taking a human life when an imminent deadly threat exists and presents itself. Within this vast range of incidents, police officers are expected to handle service calls involving citizens operating uncrewed aircraft systems (UAS) legally and illegally. Modern policing requires police officers to respond to various incidents, including authorized, criminal, and nefarious UAS operations.

State and local Law Enforcement Agencies (LEAs) are frequently the most effective entities to deter, detect, promptly investigate, and, when necessary, take enforcement actions to halt unauthorized Unmanned Aircraft Systems (UAS) operations (Justice Technology Information Center, 2016). Unfortunately, in contemporary policing, there is no mandatory training for police officers on responding to and investigating UAS incidents, which could endanger public safety (Agata & Galante, 2017). As technology evolves, police agencies must better serve and protect their citizens. This study measured the change in scores between pretest and posttest assessments, considering officers' highest educational degree (high school diploma, associate degree, bachelor's degree, or master's degree), length of service in the department, and rank. The researchers examined the online training module's impact to see if police officers' performance improved statistically.

Purpose

The study evaluates the effectiveness of the online training module, "Police Response to Uncrewed Aircraft Systems Operations," provided to a sample of Daytona Beach Police Department (DBPD) officers.

Importance of the Study

A thorough UAS response and investigation training regimen needs to be tailored for police officers. Such a program is essential for equipping them with the requisite knowledge, skills, and abilities to proficiently execute their duties in the field, ensuring effective service to their communities (Agata & Galante, 2017). Past incidents have highlighted instances where police officers halted UAS operators, inadvertently infringing their rights (FAA, 2022e). To prevent such occurrences in the future, police officers must undergo adequate training. This study represents a pioneering effort, as it addresses the deficiency of a comprehensive, standardized UAS response and investigation training program for law enforcement personnel.

Research Questions

"Does Police Response to Uncrewed Aircraft Systems Operations training received by police officers with different educational backgrounds and work experience increase their knowledge and confidence regarding their response to UAS operations incidents?" set the foundation for the study. A set of research questions was devised to explore specific facets of the study in greater detail, leading to the formulation of 10 hypotheses.

Uncrewed Aircraft Systems (UAS) in the National Airspace System (NAS)

The proliferation of UAS operations throughout the US can be divided into recreational, commercial, and public aircraft operations. Integrating UAS into the already crowded NAS of the US has presented several challenges and opportunities for the FAA and local police departments, which enforce UAS rules and regulations that have been implemented for the safety of those on the ground and in the air. The FAA Air Traffic Organization (ATO) provides daily service to more than 45,000 flights. It facilitates the transit of approximately 2.9 million airline passengers daily across an expansive airspace that

exceeds 29 million square miles (FAA, 2023e). Howard (2023) presents a preliminary analysis of 1,317 Unmanned Aircraft Systems (UAS) sighting reports from the US Federal Aviation Administration (FAA), gathered between July 1, 2020. Most crashes occur in war zones under harsh conditions, which is unlikely to happen in the USA.

The growth of UAS for recreational and commercial purposes is on a continuing upward trend. As UAS operations expand within the NAS, the likelihood of near-midair collisions (NMACs) between UAS and crewed aircraft increases (Wallace et al., 2023). Presently, the primary method of detecting UAS NMACs relies on visual detection by pilots, who then take evasive action. Pilots may report these encounters to the FAA through UAS sighting reports. The FAA uses numerous metrics to assess the potential hazards associated with UAS. Among the valuable data sources are UAS sighting reports submitted by crewed pilots and other pertinent stakeholders who have observed potentially unsafe UAS activities near airplanes, helicopters, and airports. Since the FAA began monitoring UAS sighting incidents in late 2014, there has been a considerable increase in reported sightings. In 2021 alone, the FAA received 2,595 sighting reports, representing more than double the 1,210 reports received during the initial full calendar year of tracking in 2015 (FAA, 2023b).

Due to the predicted increase in UAS operations, the FAA is attentively engaged in addressing various concerns to guarantee the secure integration of UAS within the nation's airspace (US et al. Office [USGAO], 2023). Recent progress has observed the FAA successfully concluding a pilot initiative of this system, enabling the agency to assess various technologies and formulate an implementation plan. However, while significant strides have been made, a lack of execution to provide the proper integration solutions to integrate UAS into the NAS has thrust the problem onto local police departments and their officers. The FAA has failed to develop and distribute standardized training on addressing UAS pilots flying UAS legally and illegally (FAA, 2020). This FAA failure has ultimately placed the burden on local police departments, who are responsible for responding to UAS operations calls, to provide their officers with vetted training to ensure the safety of those in the sky and on the ground, along with protecting the rights of all UAS operators who are stopped by police for investigations (Agata & Galante, 2017). As the FAA perseveres in its steadfast pursuit of the secure and seamless integration of UAS into the NAS, the journey ahead necessitates the resolution of intricate legal, technical, and policy difficulties. Regarding UAS jurisdiction and privacy matters, the legal landscape constantly evolves due to ongoing federal endeavors to establish pivotal safety and security frameworks. Additionally, the scarcity of judicial precedents concerning the compatibility of these requirements with statutory authorities further contributes to the uncertainty of the legal domain (USGAO, 2023). The need to regulate the national airspace system (NAS) for UAS has posed challenges for policymakers and businesses in the US.

Challenges and Risks Associated with UAS Operations

The FAA is committed to creating and maintaining the US's preeminent, secure, and efficient NAS. The FAA carefully upholds the required infrastructure, personnel, and operational procedures to support the world's safest and busiest aviation system (FAA, 2023e). Unfortunately, the FAA is understaffed and does not have adequate personnel to dedicate

themselves to the critical issue of UAS integration into the NAS safely and efficiently. President Biden's fiscal 2024 budget proposes a 17% funding increase to enhance FAA facilities and systems (Katz, 2023). However, addressing the crisis at the FAA will not be immediate, as it takes one to three years to train and certify new employees, with approximately 40% of hires dropping out during the training process (Katz, 2023).

Human error is a significant risk factor in UAS operations, encompassing inadequate operator response, mission planning errors, and improper maintenance of the UAS itself. A study conducted by the Air Force Research Laboratory on UAS Predator mishaps indicated that once system failures occurring in the initial years of operation are addressed and mitigated, various human errors occur as the leading risk factor (Herz, 2008). To mitigate these risks, it is critical to prioritize training new and current UAS operators, focusing on developing their operational skills and knowledge base about the UAS and the environment they are operating in to minimize the incidence of human errors.

Finn and Wright (2012) emphasize the importance of addressing privacy and security concerns associated with unmanned aircraft systems (UAS). They highlight the potential infringement of privacy rights due to UAS's capability to capture images and collect data. Precise data collection, retention, consent, and notice guidelines are necessary to ensure responsible and ethical use. Moreover, UAS's vulnerability to cybersecurity threats necessitates robust security measures like encryption, secure data storage, and communication channels. Collaboration between regulatory bodies, operators, and privacy advocates is crucial to developing comprehensive regulations balancing technology benefits with privacy protection. Implementing privacy-enhancing technologies, cybersecurity measures, and public awareness can mitigate risks and promote responsible UAS use, requiring coordinated efforts from multiple government agencies.

Ensuring the reliability and maintenance of unmanned aircraft systems (UAS) is critical for safe and efficient operations, as highlighted by Mrusek et al. (2018). Regular maintenance and inspections are vital for identifying and addressing potential issues or malfunctions. Proper maintenance includes routine checks, repairs, and component replacements to prevent unexpected failures during flight. Adhering to original equipment manufacturers' (OEM) guidelines and timely inspections enhance overall reliability and reduce the risk of operational disruptions or accidents. Organizations should establish robust maintenance programs with trained personnel, prioritize schedule adherence, and promptly address any identified issues to minimize risks. UAS operators can enhance safety and effectiveness across various applications by maintaining high-reliability standards and performing diligent maintenance.

Mid-air collisions between unmanned and crewed aircraft are a significant concern in integrating UAS operations into the National Airspace System (NAS). Current methods rely on visual detection by crewed aircraft pilots, but research on its effectiveness needs to be more conclusive. Standardization and further investigation are needed to ensure safe separation. The FAA mandated Automatic Dependent Surveillance-Broadcast (ADS-B, 2023) capabilities by 2020 to enhance air traffic management, providing crewed pilots with GPS-based aircraft positioning and other data. However, UAS are prohibited from using ADS-B, creating safety concerns by hindering mutual visibility between crewed and uncrewed aircraft. The lack of

alignment between remote identification (RID) regulations for unmanned aerial systems (UAS) and the utilization of ADS-B presents significant challenges to airspace safety. UAS operators are mandated to adhere to RID regulations, necessitating the transmission of essential flight information to other UAS operators (Tedeschi et al., 2024)

Existing UAS Training Gaps and Lack of Standardization

The FAA emphasizes collaborating with law enforcement agencies to investigate risky UAS operations to maintain aviation safety (USGAO, 2019). However, FAA inspectors need help obtaining crucial data for thorough investigations, which hinders their effectiveness (Latorella & Prabhu, 2000). Law enforcement's role is pivotal, with police reports being valuable sources of information, but there needs to be more clear guidance and training for officers. Bridging this gap requires comprehensive training and protocols to enable law enforcement to effectively respond to UAS incidents and share pertinent information with the FAA. Despite efforts, communication between the FAA and law enforcement could be more consistent, necessitating a standardized approach to ensure all agencies are adequately informed and prepared to assist in addressing unsafe UAS operations nationwide (FAA, 2022b).

Policing in the Modern Era and the Need for UAS Response Training

Morin et al. (2017) highlight the disparities between law enforcement and the public regarding policing perspectives and policy matters. While police officers advocate for increased presence for effective community patrolling, the public often disagrees. Officers face challenges like disruptive behavior and insufficient resources but express dedication to their departments. Regarding UAS incidents, law enforcement must establish robust policies and response protocols to manage emerging challenges and ensure public safety. It is crucial to differentiate between lawful and unlawful UAS operations and train officers accordingly to interact safely with UAS operators for the well-being of all (Agata & Galante, 2017).

The rise of UAS technology brings new risks, including potential criminal and terrorist exploitation, necessitating measures to safeguard public safety (US Department of Justice [USDOJ], 2023). Concerns include prohibited surveillance, chemical attacks, and kinetic assaults on gatherings or government facilities. Police departments must be equipped to counter these threats for national security.

In contemporary policing, officers enforce laws, ensure justice, and protect individuals. However, there are instances of officers engaging in misconduct, such as evidence suppression or excessive force, which can harm individuals and violate their rights. Police officers can be held liable for such actions if they violate constitutional rights while acting officially. Common claims against officers include unlawful searches, illegal arrests, and the use of excessive or deadly force. Proper training is essential to mitigate such risks. Police departments also hold themselves accountable for officers' conduct and can face legal proceedings for negligence, where failure to exercise reasonable care harms others (Novak et al., 2003). Accountability is crucial for maintaining trust and integrity within law enforcement.

Comprehensive police training is essential for reducing liability and ensuring the safety of both officers and the community. Adequate training enables officers to apply the law accurately, handle complex situations effectively, and foster a culture of accountability within police departments. Legal precedents, like the City of Canton v. Harris case, underscore the duty of municipalities to provide thorough training to their officers (City of Canton, Ohio v. Harris, 1989). Training should address evolving policing demands, cultural competency, and the proper use of advanced technologies (Agata & Galante, 2017). Moreover, clear and regularly updated policies are crucial to guide officers' conduct and procedures, aligning with societal needs and legal standards. Training programs should effectively communicate and educate officers on these policies to ensure their understanding and application in real-world scenarios.

The FAA guides law enforcement agencies (LEAs) in addressing unauthorized and unsafe UAS operations through a comprehensive document. It outlines legal foundations and offers practical advice for collaboration between LEAs and the FAA (FAA, 2022c). However, the FAA's approach to ensuring compliance through "voluntary compliance" lacks effectiveness due to insufficient educational efforts and the burden placed on UAS operators. Local police officers often respond to UAS incidents without proper training, despite their enforcement role alongside the FAA. While the FAA has enforcement measures, its capacity is limited, necessitating collaboration with local police. State and local police have varying capabilities and jurisdictional limitations but are crucial in deterring unauthorized UAS operations. Optimizing enforcement requires strong cooperation between the FAA and local police, leveraging their strengths and resources.

Methodology

This study utilized a self-selection sampling method, allowing officers the freedom to opt into participation. This approach fostered heightened engagement and ensured the inclusion of diverse perspectives. Ethical considerations were meticulously observed throughout the research process. This involved safeguarding participant data confidentiality, prioritizing the welfare of voluntary participants, and adhering to principles of equitable treatment.

Participants completed demographic questionnaires, self-efficacy surveys, pretests, an online training module, and posttests to facilitate comprehensive data collection. Authorization from the DBPD Chief of Police was obtained to disseminate the research training program through official channels, inviting officers to participate voluntarily in a courteous manner.

To ensure data security and confidentiality, Google Forms and Wix software were employed to house data collection documents and training materials on a secure Google Drive account accessible only to the researcher. Before commencing the online training modules, participants underwent a 20-question multiple-choice assessment related to UAS incident response and investigations to gauge their initial understanding of the subject matter.

The online training modules were created by Anthony Galante and covered various topics, including understanding the threat, defining uncrewed aircraft systems, regulation and airspace domain, identifying legal and illegal UAS operations, initial officer response to UAS operations, response continuum, and required response documentation process and completion.

This self-paced training took approximately 60 minutes to complete. Although Galante is esteemed in his field, he prioritized transparency by disclosing his background and affiliations. The training content underwent rigorous peer review to incorporate diverse perspectives. Suggestions for replication in future research were made to identify and mitigate potential biases.

Participants were requested to complete a demographic and self-efficacy questionnaire upon volunteering for the study. These surveys delved into participants' perspectives and experiences with UAS while on duty as police officers. After completing the surveys, participants underwent a 20-question multiple-choice pretest, online training modules, a 20-question posttest, and a post-training self-efficacy questionnaire. This comprehensive process took approximately 60 minutes to finish. All active police officers from the DBPD were eligible to participate, ensuring demographic diversity within the participant pool and enhancing the study's generalizability. Ten hypotheses were tested using the paired samples t-test, which compared the means of two measurements taken from the same participant. The disparity between pretest and posttest scores was calculated, considering various demographic variables collected for each participating police officer. To ensure trustworthiness in the study, the link for the online training was only issued to the official police department email addresses of all sworn DBPD police officers, as this was the study's target group. Before conducting further analysis, the normality of the data for data was assessed using the Shapiro-Wilk test in SPSS, and the data was approximately normally distributed.

Participants

The research study drew its population from the Daytona Beach Police Department (DBPD), which comprises 243 sworn officers, according to Daytona et al. Department (2023). The estimated sample size for this study was approximately 82 officers, constituting roughly one-third of the total number of sworn officers in the DBPD. Given the demanding responsibilities of DBPD's patrol officers in responding to various community calls for service, the sample was obtained through a non-probability self-selection method. Only active DBPD police officers were used in this research study because the training prepared and delivered via the online training modules was specifically designed for active police officers who currently respond to calls for service involving legal and illegal UAS operations.

Results

Respondent Demographics

The sample consisted of 82 certified police officers from DBPD who volunteered to participate in the applied doctoral project. Of the 82 participants, 70 (85.4%) were male, 11 (13.4%) were female, and one (1.2%) preferred not to answer. The minimum age of the participants was 19 years, and the maximum age was 59, for a range of 40 years. The mean age of the participants was 35.71 years. Participants in the study were officers, sergeants, and other ranks. As for the ranks of participants, 66 (80.5%) were officers, 10 (12.2%) were sergeants, and 6 (7.3%) were other ranks. As for the years of service participants, 57 (69.5%) participants had

0-5 years of service, 10 (12.2%) participants had 6-10 years of service, and 15 (18.3%) participants had ten or more years of service. This study included participants with varying levels of completed education with the following breakdown: 36 (43.9%) participants completed high school, 10 (12.2%) participants earned an associate degree, 22 (26.8%) participants earned a bachelor's degree, and 14 (17.1%) participants earned a master's degree. It was found that 6 out of 9 respondents (equivalent to 6.7%) had undergone advanced police training related to Unmanned Aerial Systems (UAS) at the DBPD. In contrast, the majority, comprising 76 respondents (85.4%), had not received any such training. Regarding a policy guiding responses to UAS/drone incidents within DBPD, 55 respondents (61.8%) acknowledged the presence of such a policy. In comparison, 27 respondents (30.3%) expressed skepticism. Furthermore, a significant proportion of respondents, 80 individuals (89.9%), possessed a Federal Aviation Administration (FAA) crewed pilot certificate, underscoring their credentials in manned aviation. Conversely, only two respondents (2.2%) lacked such certification. Regarding call volume experienced by respondents during their tenure at DBPD, a substantial majority, 82 respondents (92.1%), reported handling between 0 and 5 calls. Conversely, a minority of 7 respondents (7.9%) indicated dealing with 21 or more calls, highlighting potential variations in workload distribution among personnel.

Instrument Validity and Reliability Analysis

Factor analysis was performed on the measurement data. Principal Component Analysis served as the extraction method, and the VARIMAX rotation method was utilized to enhance interpretability. A single component was extracted. The item correlation coefficients revealed satisfactory factor loadings exceeding the threshold (>0.5) (Chetty, 2015).

Cronbach's Coefficient Alpha, a frequently employed technique in social science research, was used to assess the construct's internal consistency and reliability. This assessment. Typically, an alpha value exceeding 0.7 is deemed satisfactory, although, for exploratory investigations, this threshold may be as low as 0.60 (Nunnally, 1978; Hair et al., 1998). In this study, the alpha value obtained was 0.951. This research seeks to test the following hypothesis：

Hypothesis 1

H1: Posttest knowledge test scores from the UAS response and investigation training delivered to a sample of DBPD police officers will be higher than pretest knowledge test scores.

A paired samples *t*-test was conducted to compare the mean UAS knowledge scores before and after the UAS response and investigation training. The two-tailed *t*-test revealed a statistically significant difference between the mean UAS knowledge scores before and after the UAS response and investigation training t (15.057) = 2.276. The mean UAS knowledge score before the UAS response and investigation training was 54.63 (SD = 20.288), whereas the mean UAS knowledge score after the UAS response and investigation training was 88.90 (SD = 5.388). These results indicate that the mean scores significantly increased before and after the UAS response and investigation training. These observed findings provide support for H1.

Hypothesis 2

H2: Post-training self-efficacy confidence scores from the UAS response and investigation training delivered to a sample of DBPD police officers will be higher than pretraining self-efficacy confidence scores.

A paired samples t-test was conducted on self-efficacy confidence scores before and after UAS response training, revealing a significant difference ($t(25.761) = 2.106$). From a sample of 82 DBPD officers, the mean pre-and post-test scores were estimated at 54.25 (95% CI [50, 58]). Pre-training confidence scores averaged 9.394 (SD = 14.186), while post-training scores averaged 63.644 (SD = 16.064). This indicates a significant increase in self-efficacy confidence after the UAS training, supporting H2.

Hypothesis 3

H3: Posttest-training scores from the UAS response and investigation training delivered to a sample of DBPD officers with a high school diploma as their highest level of education will be higher than pretest-training scores.

A paired samples t-test was conducted to assess the UAS knowledge scores of officers with a high school diploma before and after UAS response and investigation training, revealing a significant difference ($t(10.286) = 3.389$). From a sample of 36 DBPD officers, the estimated mean pre-and post-test scores were 34.861 (95% CI [28, 42]), with a margin of error of ±2 points. Before training, the mean UAS knowledge score was 55.14 (SD = 19.946), increasing to 90.00 (SD = 3.780) after training, as depicted in Table 9. These results demonstrate a significant improvement in scores post-training, supporting H3 and indicating a notable enhancement in UAS knowledge levels among officers with a high school diploma.

Hypothesis 4

H4: Posttest-training scores from the UAS response and investigation training delivered to a sample of DBPD officers with an associate degree, as their highest level of education will be higher than pretest-training scores.

A paired samples t-test was conducted to assess the UAS knowledge scores of officers with an associate degree before and after UAS response and investigation training, showing a significant difference ($t(4.807) = 6.344$). From a sample of 10 DBPD officers, the estimated mean pre-and post-test scores were 30.5 (95% CI [16, 45]), with a margin of error of ±2 points. Pre-training, the mean UAS knowledge score was 56.00 (SD = 21.833), increasing to 86.50 (SD = 6.258) post-training, indicating a significant improvement. These results support H4, affirming a substantial enhancement in UAS knowledge levels among officers with an associate degree following the training.

Hypothesis 5

H5: Posttest-training scores from the UAS response and investigation training delivered to a sample of DBPD officers with a bachelor's degree as their highest level of education will be higher than pretest-training scores.

A paired samples t-test compared the UAS knowledge scores of DBPD officers with a bachelor's degree before and after UAS response and investigation training, showing a significant difference ($t(6.744) = 4.395$). From a sample of 22 officers, the estimated mean pre- and post-test scores were 29.773 (95% CI [21, 39]), with a margin of error of ±2 points. Before training, the mean UAS knowledge score was 58.18 (SD = 20.210), increasing to 87.95 (SD = 6.484) post-training, indicating a significant improvement. These results support H5, highlighting a notable enhancement in UAS knowledge levels among officers with a bachelor's degree following the training.

Hypothesis 6

H6: Posttest-training scores from the UAS response and investigation training delivered to a sample of DBPD officers with a master's degree as their highest level of education will be higher than pretest-training scores.

A paired samples t-test compared the UAS knowledge scores of DBPD officers with a master's degree before and after UAS response and investigation training, revealing a significant difference ($t(7.504) = 5.663$). From a sample of 14 officers, the estimated mean pre- and post-test scores were 42.50 (95% CI [30, 55]), with a margin of error of ±2 points. Pre-training, the mean UAS knowledge score was 46.79 (SD = 20.344), rising to 89.29 (SD = 6.157) post-training, indicating a significant improvement. These results support H6, indicating a substantial increase in UAS knowledge levels among officers with a master's degree following the training.

Hypothesis 7

H7: Posttest-training scores from the UAS response and investigation training course delivered to a sample of DBPD sergeants, lieutenants, captains, and chiefs will be higher than pretest-training scores.

A paired samples t-test was conducted to assess the mean UAS knowledge scores of DBPD sergeants, lieutenants, captains, and chiefs before and after UAS response and investigation training, revealing a significant difference ($t(7.780) = 5.222$). From a sample of 16 officers, the estimated mean pre-and post-test scores were 40.625 (95% CI [29, 52]), with a margin of error of ±2 points. Pre-training, the mean UAS knowledge score was 49.06 (SD = 20.430), rising to 89.69 (SD = 7.181) post-training, indicating a significant improvement. These results support H7, indicating a substantial increase in UAS knowledge levels among DBPD sergeants, lieutenants, captains, and chiefs following the training.

Hypothesis 8

H8: Posttest-training scores from the UAS response and investigation training delivered to a sample of DBPD officers with 0-5 years of service with the DBPD will be higher than pretest-training scores.

A paired samples t-test was employed to compare the mean UAS knowledge scores of DBPD police officers with 0-5 years of service before and after UAS response and investigation training, revealing a significant difference ($t(11.561) = 2.663$). From a sample of 57 officers, the estimated mean pre- and post-test scores were 30.789 (95% CI [25, 36]), with a margin of error of ±2 points. Pre-training, the mean UAS knowledge score was 57.81 (SD = 19.888), increasing to 88.60 (SD = 5.240) post-training, indicating a significant improvement. These results support H8, suggesting a notable increase in UAS knowledge levels among DBPD police officers with 0-5 years of service following the training.

Hypothesis 9

H9: Posttest-training scores from the UAS response and investigation training delivered to a sample of DBPD officers with 6-10 years of service with the DBPD will be higher than pretest-training scores.

A paired samples t-test was conducted to compare the mean UAS knowledge scores of DBPD police officers with 6-10 years of service before and after UAS response and investigation training, revealing a significant difference ($t(5.792) = 7.424$). From a sample of 10 officers, the estimated mean pre- and post-test scores were 43.00 (95% CI [26, 60]), with a margin of error of ±2 points. Pre-training, the mean UAS knowledge score was 48.00 (SD = 22.509), increasing to 91.00 (SD = 5.164) post-training, indicating a significant improvement. These results support H9, suggesting a substantial increase in UAS knowledge levels among DBPD police officers with 6-10 years of service following the training.

Hypothesis 10

H10: Posttest-training scores from the UAS response and investigation training delivered to a sample of DBPD officers with ten years or more of service with the DBPD will be higher than pretest-training scores.

A paired samples t-test compared the mean UAS knowledge scores of DBPD officers with ten years or more of service before and after UAS response and investigation training, showing a significant difference ($t(8.968) = 4.646$). From a sample of 15 officers, the estimated mean pre- and post-test scores were 41.667 (95% CI [32, 52]), with a margin of error of ±2 points. Pre-training, the mean UAS knowledge score was 47.00 (SD = 18.400), increasing to 88.67 (SD = 6.114) post-training, indicating a significant improvement. These results support H10, indicating a notable increase in UAS knowledge levels among DBPD officers with ten years or more of service following the training.

Analysis & Discussion

Using paired samples t-tests, 82 DBPD officers with diverse demographics and educational backgrounds (high school diploma, associate degree, bachelor's degree, and master's degree) were evaluated to see whether the online training they participated in affected their knowledge base and self-efficacy by comparing their pre-training test scores with their post-training test scores. According to the data, online training substantially increased UAS knowledge scores across all education levels, with large effect sizes. In addition, officers with higher levels of education had higher post-test scores. Implementing the UAS response and investigation training resulted in a substantial increase in the UAS knowledge and confidence of police officers, confirming the hypotheses and answering the research questions.

Training and adherence to constitutional principles are essential, as demonstrated by legal precedents such as *Monell v. Department of Social Services* (1978) and *Popow v. City of Margate* (1979). In 1978, the Department of Social Services established the municipal liability doctrine in civil rights cases against local government entities. Local governments could be held liable for constitutional violations caused by their policies, practices, or customs, making it easier for individuals to seek redress for civil rights violations by municipalities and prompting changes in government practices to prevent them (*Monell v. Department of Social Services,* 1978). In 1979, the courts emphasized the need for law enforcement firearms training to reflect real-world conditions. In *Popow v. City of Margate*, an officer accidentally shot and killed Mr. Popow while pursuing a suspect. The court found the officer's training grossly inadequate, lacking instruction on low-light conditions, moving targets, and firing in residential areas (*Popow v. City of Margate*, 1979). This case underscores the imperative for police departments to furnish their officers with essential training tailored to the situations they may encounter during their official duties.

When addressing UAS operations, developing comprehensive policies and procedures becomes imperative. This process begins with educating police department administrators and other local, state, and federal agencies. Collaboration between all agencies that have the potential to work in a jurisdiction is critical for success. Ongoing education, training, collaboration between officers and dispatch personnel, and the integration of community policing principles contribute to an effective response to UAS incidents (FAA, 2022c). Public education initiatives and community partnerships further enhance compliance with FAA regulations and promote trust between law enforcement and the community. Addressing UAS challenges requires a comprehensive approach that prioritizes education, training, community collaboration, and adherence to FAA regulations. By implementing these strategies, police departments can respond effectively to UAS incidents, foster stronger community relationships, and promote public safety (FAA, 2018).

It is imperative that police departments establish a mandatory requirement for UAS response and investigation training across all officer ranks due to the effectiveness of the training. This training should be mandatory for all law enforcement agencies in the United States, as this emerging technology can be used for criminal purposes, such as when police officers must respond and investigate during normal patrol activities. The FAA has provided limited guidance to police departments on the fundamental steps for responding to UAS operations. Police departments must educate and train their police officers of all ranks and

experience levels before they engage with UAS operators in the field due to the natural complexity of aviation regulations and potential jurisdictional issues that arise when addressing UAS operations (FAA, 2018).

The findings from this study provide evidence of a significant positive difference between the mean UAS knowledge scores before and after the UAS response and investigation training. The posttest knowledge test scores were significantly higher than the pretest knowledge test scores. This study also discovered that the performance of DBPD officers who participated in the online training improved significantly, regardless of the officers' education level, rank, or length of service.

In light of the constant evolution in the field, police officers must undergo specialized UAS response and investigation training to effectively address the UAS calls they are likely to encounter during their tour of duty. To ensure the continued significance of this training, police departments should offer routine refresher courses while expanding the curriculum to encompass various real-world UAS scenarios and recent regulatory advancements. Given the mandatory familiarity with the NAS, FAA regulations, and pertinent aviation state statutes, the significance of ongoing and current training in responding to and investigating UAS incidents cannot be overstated. More extensive and diverse study samples are recommended for a more comprehensive evaluation of the program's impact and long-term studies on training outcomes.

It is crucial to highlight the importance of establishing efficient officer feedback systems and community involvement mechanisms concerning the execution and continuation of UAS training programs designed for police officers. Given that these training efforts are focused on providing officers with the essential abilities to address UAS operations proficiently, it becomes imperative to uphold an ongoing avenue of communication connecting training coordinators, officers, and the local communities they serve. Integrating officer feedback mechanisms allows those directly engaged in the training to provide insights into its effectiveness, practicality, and relevance in real-world scenarios. Police officers on the frontlines possess invaluable insights into the challenges they encounter when dealing with UAS incidents, and their input can contribute to refining the training content, ensuring it addresses the most pertinent issues they face. Regular surveys, focus groups, and open discussions can allow officers to share their experiences, suggest improvements, and voice concerns.

Moreover, establishing robust community engagement strategies alongside officer feedback mechanisms can bridge the gap between law enforcement and the public. As UAS technology continues to influence various aspects of society, police officers need to be attuned to community-specific concerns and expectations regarding using UAS. Law enforcement agencies can better align the training content with community needs and expectations by involving community members, local stakeholders, and advocacy groups in the training development and evaluation.

Limitations

Several limitations may be associated with the study population, stemming from factors such as sample size, selection process, or participant characteristics. The delivery of

online questionnaires, training, and testing materials relied on a self-paced online training video and an internet browser. This approach could potentially introduce bias, particularly among participants lacking experience with computers and computer-based training, thereby influencing research outcomes. Additionally, the reliance on self-reported self-efficacy levels from participants regarding UAS incident response may introduce subjectivity into the results. The study exclusively focused on DBPD officers, limiting the generalizability of findings. Moreover, participants could not seek clarification or ask questions about the material presented in the online training video, potentially impacting the comprehensiveness of the training and, consequently, the study's outcomes.

Conclusion

The integration of technology into the community contributes to the dangers faced by police officers during routine patrols in the 21st century. The research evaluated how practical the UAS response and investigation training was in enhancing police officers' understanding and confidence regarding responding to and handling UAS incidents. The study focused on the DBPD, where 82 officers voluntarily participated in a self-selection sampling method, ensuring diverse perspectives were included. Data was collected through questionnaires, surveys, pretests, online training modules, and posttests. The study analyzed different research questions and hypotheses, comparing participants' pretest and posttest scores through paired samples *t*-tests. Encouragingly, all groups, regardless of educational backgrounds, rank, and service years, showed significant improvement in UAS knowledge and self-efficacy confidence after completing the training, with notably large effect sizes.

Recommendations for Practice

This study is beneficial for police administrators responsible for providing mandatory training required to equip officers with the correct tools to perform their everyday duties as police officers. This study may provide police administrators with the data and findings necessary to justify the implementation of this training to their superiors. By providing this training, police administrators can reduce their agency's liability. The results of this study may be utilized to demonstrate the validity of the training to other police organizations so that it can be implemented in police agencies across the United States.

This study is also advantageous for those UAS operators who are lawfully operating their UAS in the NAS since they will engage with police who respond to and investigate UAS occurrences effectively without violating UAS operators who operate legally. The results of this study may inform police officers, police executives, and criminal justice researchers how to improve UAS response and investigation training throughout the United States. The results may also inform policymakers and executive law enforcement leaders how they can provide critical support and training for their officers through legislative and departmental policy actions.

Recommendations for Future Research

The results of this study may be utilized to demonstrate the validity of the training to other police organizations so that it can be implemented in police agencies across the United States. Multiple paths for future research have surfaced since the beginning of our study and results from the data. In addition to a more extensive and diverse sample, future research projects should consider involving multiple police departments nationwide. Collaborative efforts across various jurisdictions would not only enrich the research findings but also provide a broader perspective on the efficacy of the training program in different operational environments and legal frameworks. Researchers can gain insights into how the program's impact varies across contexts by involving departments with varying UAS-related incidents, operational sizes, and training practices. Furthermore, to gain a more comprehensive understanding of the long-term effects of the training program, subsequent research should consider conducting longitudinal studies. Tracking the performance and responses of officers over an extended period would enable researchers to gauge the durability of the training outcomes and assess whether the acquired knowledge and self-efficacy improvements are maintained over time. Also, future research should explore long-term effects and contributing factors to validate these findings further.

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APPENDIX A: Questionnaire

Self-efficacy Questionnaire (Pre-Training & Post-Training)

This questionnaire is designed to help us better understand how police officers understand concepts and tasks associated with responding to UAS/drone incidents while on duty.

Please rate your degree of confidence by recording a number from 0 (cannot do) through 100 (certain can do) of how confident you think you are at the following items.

1. Knowledge of Daytona Beach Police Department (DBPD) Uncrewed Aircraft System (UAS) policy	
2. Knowledge of applicable federal UAS/drone laws	
3. Skill to successfully apply federal UAS/drone laws	
4. Knowledge of applicable state UAS/drone laws	
5. Skill to successfully apply state UAS/drone laws	
6. Knowledge to identify a UAS/drone	
7. Knowledge to identify legal UAS/drone operations	
8. Knowledge to identify illegal UAS/drone operations	
9. Skill to find the UAS/drone operator	
10. Knowledge of what questions to ask the operator to determine the type of UAS/drone flight (recreational, part 107, public safety)	
11. Knowledge of Federal Aviation Administration (FAA) Airspace	
12. Knowledge of the proper UAS response continuum	
13. Knowledge of the required UAS response documentation process and completion	