Technical Review

https://doi.org/10.12985/ksaa.2025.33.1.071
ISSN 1225-9705(print) ISSN 2466-1791(online)

A Study on the Integration of Evidence-Based Training (EBT) and Digital Technologies to Enhance Aviation Safety

Sang-Yong Park*

ABSTRACT

This study explores the integrated application of Evidence-Based Training (EBT), an International Civil Aviation Organization (ICAO) standard, with digital technologies to enhance aviation safety in the era of digital transformation. EBT strengthens pilots' practical response capabilities based on real flight data and accident analysis, while digital technologies improve training effectiveness through data analytics, advanced simulators, and virtual reality (VR). The study underscores the necessity of such advancements to prevent incidents like the 2024 Muan International Airport accident and analyzes cases from ICAO, EASA, FAA, and CAA. Key challenges in the domestic training system include a lack of digital infrastructure, insufficient instructor competency, and inadequate data management. To address these issues, the study proposes solutions such as digital infrastructure development, instructor training, legal support, and the establishment of a structured data management system to effectively implement EBT in South Korea. Additionally, the study suggests introducing digital EBT into student pilot training to enhance safety capabilities from the early stages. The findings confirm that digital EBT has the potential to revolutionize aviation safety culture and contribute to accident prevention. However, limitations remain regarding cost and feasibility analysis, highlighting the need for future economic viability assessments and empirical research.

Key Words : Evidence-Based Training(EBT, 증거기반훈련), Digital Integration(디지털 융합), Aviation Safety Enhancement(항공안전제고), Data-Driven Training(데이터 기반 훈련), Safety Capability Reinforcement(안전역량강화)

Ⅰ. Introduction

The aviation industry prioritizes safety and reliability above all else. Recent aviation accidents have underscored the necessity for modernizing pilot training and integrating digital technologies. Notably, the Evidence-Based Training(EBT) framework proposed by the International Civil Aviation Organization(ICAO) leverages real flight data and accident analyses to enhance pilot competencies. The integration of digital technology into EBT has the potential to further elevate aviation safety standards.

According to national transportation statistics, from 2010 to 2023, a total of 60 fatalities and 250 injuries occurred due to aviation accidents, resulting in 310 casualties. Additionally, on December 29, 2024, a tragic mid-air collision involving a Jeju Air passenger aircraft at Muan International Airport resulted in 179 fatalities out of

Received: 27. Feb. 2025, Revised: 28. Feb. 2025, Accepted: 05. Mar. 2025

* Professor, Department of Aviation Operations, Korea National Transport University
Corresponding Author E-mail : parksy@ut.ac.kr
Corresponding Author Address : Daehak-ro 50, Chungju-si, Chungcheongbuk-do, S. Korea

181 passengers. This incident marks the first fatal accident involving a Korean-registered commercial aircraft in 11 years and the third deadliest in South Korean aviation history, emphasizing the urgent need for digitalized pilot training and enhanced safety protocols.

Aviation safety remains a global challenge. According to the International Air Transport Association(IATA) 2023 report, the number of aviation accidents increased compared to 2022, with pilot mismanagement of abnormal situations identified as a key contributing factor. The United States and Europe have also witnessed frequent incidents attributed to extreme weather conditions, airport congestion, and human errors. In this context, ICAO's EBT, when integrated with digital technologies, plays a crucial role in strengthening pilots' crisis management capabilities and enhancing aviation safety. Digital transformation is revolutionizing the aviation industry, including pilot training, through the adoption of data analytics, advanced simulators, virtual reality(VR), and artificial intelligence(AI) (Maurino, 1995).

EBT, structured in accordance with ICAO Doc 9995[1)], provides real-time data feedback and tailored training, significantly contributing to contemporary aviation safety enhancements. The aim of this study was to explore the integrated application of ICAO's EBT framework and digital technologies to enhance aviation safety and proposes strategic implementations within South Korea's pilot training system.

II. Theoretical Analysis

2.1 Theoretical Background

2.1.1 Definition and Evaluation

2.1.1.1 Definition of EBT

EBT is a pilot training program designed to enhance aviation safety, developed based on ICAO Doc 9995, incorporating real flight data and accident analysis. The program focuses on cultivating the necessary competencies for pilots to operate safely in real flight environments while adhering to aviation operation regulations outlined in Doc 9868 and Annex 6(Stolzer, 2015).

2.1.1.2 Evaluation of EBT

EBT consists of three primary stages: Evaluation, Manoeuvres Training, and Scenario-Based Training. The first stage, Evaluation, comprehensively assesses pilots' situational awareness and problem-solving skills (Endsley, 1995). The second stage, Manoeuvres Training, emphasizes appropriate responses to emergency situations. In the third stage, Scenario-Based Training, pilots undergo training in realistic situations to ensure adaptability across various flight environments. The evaluation criteria for EBT must meet aviation safety regulation requirements, necessitating a checklist for assessing emergency response capabilities and flight skills. This evaluation system is designed to track and document pilot performance at each training stage, ensuring compliance with legally mandated safety standards during actual flight operations.

2.2 International Case Studies

2.2.1 ICAO

2.2.1.1 Integration of ICAO Standard EBT and Digital Technology

ICAO's EBT program is designed to enhance aviation safety by utilizing real flight data and accident analysis, with its effectiveness maximized through the integration of digital technology. EBT consists of three stages: Evaluation, Manoeuvres Training, and Scenario-Based Training. First, the Evaluation stage employs digital tools to assess pilots' situational awareness and problem-solving skills. Second, the Manoeuvres

1) Doc9995 : Manual of Evidence-based Training, First Edition, 2013.

Training stage uses simulators to practice emergency response capabilities. Third, the Scenario-Based Training stage immerses pilots in realistic digital environments to experience various crisis situations.

Digital technology enhances the effectiveness of each EBT stage. For instance, Flight Data Analysis(FDA) can be used to examine pilots' flight patterns, enabling the development of individualized training plans. The use of VR and AI allows for safe simulation of abnormal situations, such as complex weather conditions or system failures, thereby strengthening pilots' real-world response capabilities. This represents a key approach to improving aviation safety, aligning with ICAO standards while adopting training methods suited for the digital transformation era.

2.2.1.2 Utilization of Digital Technology in ICAO's EBT

Integrates digital technology into EBT to enhance aviation safety. Digital data collection occurs through airline operational data, Safety Management Systems(SMS), and FDA. Airline operational data identify threats and errors encountered during actual flights, while SMS provides safety reports and accident analysis. FDA analyzes flight recorder data to track the frequency of abnormal approaches and Traffic Collision Avoidance System(TCAS) alerts. This data is then integrated into digital platforms for comprehensive analysis and training scenario development.

ICAO's digital approach facilitates real-time feedback systems that immediately assess training performance, enhancing both technical proficiency and non-technical competencies such as situational awareness, decision-making, and teamwork. This plays a crucial role in preventing recent aviation safety incidents.

2.2.2 European Union Aviation Safety Agency (EASA)

The EASA defines operational requirements through Part-ORO(Organization Requirements for Air Operations), which establishes standards for airline operations and ensures that pilot training programs, including EBT, comply with legal requirements. EBT enhances pilots' technical skills and attitudes necessary for real flight operations, fostering their ability to adapt flexibly to unpredictable emergency situations. Additionally, EASA's Part-FCL(Flight Crew Licensing) regulation clarifies assessment and qualification standards for EBT, providing a legal framework for training organizations to design compliant EBT programs. The following details outline the key components of EBT and the regulatory standards that support them.

2.2.3 Federal Aviation Administration (FAA)

FAA integrates EBT with digital technology under Part 121 regulations. The FAA allows airlines to implement customized training programs, optimizing them through digital data analysis. By combining simulator training data with flight operational data, the FAA identifies pilot weaknesses and provides targeted training to address them. The FAA's digital feedback system stores training results in a database, contributing to the prevention of recent aviation safety incidents.

2.2.4 Civil Aviation Authority (CAA) of the United Kingdom

The CAA of the United Kingdom has established regulatory frameworks for EBT, reinforcing its training and assessment systems. The CAA's CAP 737[2] regulation mandates the incorporation of non-technical competencies as a critical

2) CAP 737: Civil Aviation Publication, Crew Resource Management Training, 29 November 2006.

component of EBT. This directive requires the assessment of pilots' situational awareness, communication skills, and decision-making abilities throughout the training process. CAP 737 applies to all Approved Training Organizations (ATO) within the UK, ensuring that pilot training programs systematically evaluate and integrate non-technical competencies into their curriculum.

2.3 Comparative Analysis of International Cases: Commonalities and Distinctive Features

2.3.1 Commonalities

International aviation regulatory bodies, including ICAO, EASA, FAA, and CAA, share a common objective of enhancing pilot training quality and improving aviation safety through the integration of EBT and digital technology. These organizations adopt three key principles within EBT—data-driven decision-making, real-time feedback, and personalized training—leveraging digital technologies for implementation.

First, data-driven decision-making serves as a fundamental pillar of both EBT and digital integration. EBT, based on ICAO Doc 9995, utilizes FDA, airline operational data, and SMS records to design training programs. For instance, abnormal approach incidents (e.g., excessive landing speeds) or TCAS alerts are analyzed to identify recurrent risk factors faced by pilots. This data is managed through digital platforms, and all international regulatory agencies utilize such analytics as the foundation for developing training scenarios. This approach moves beyond traditional standardized training models by incorporating real-world operational environments, thereby enhancing pilots' practical response capabilities.

Second, real-time feedback is another shared feature enabled by digital technology. During EBT training, digital simulators and data analytics tools continuously record and evaluate pilot performance. For example, in simulated engine failure exercises, the digital system tracks pilots' reaction times, decision-making processes, and crew coordination in real time. This data is immediately processed and provided as post-training feedback, allowing pilots to rapidly identify strengths and areas for improvement. ICAO has adopted this method to enhance training effectiveness and repetition, and other aviation authorities have implemented similar systems to maximize training efficiency.

Third, personalized training is a common outcome of integrating EBT with digital technology. By leveraging digital analytics, training programs can be tailored to individual pilots' flight experience, skill levels, and specific weaknesses. For example, if data reveals that a pilot struggles with decision-making in adverse weather conditions, digital simulators can adjust scenarios to focus on such challenges. This individualized approach, aligned with ICAO standards, is widely adopted by all major regulatory agencies, ensuring a consistent level of pilot competency. This strategy is increasingly recognized as a critical factor in reducing aviation safety incidents.

These shared characteristics are rooted in ICAO's EBT framework and are realized through digital technology. Data-driven decision-making provides a scientific foundation for training, real-time feedback enhances learning effectiveness, and personalized training strengthens pilots' individual competencies. Ultimately, by implementing digitalized EBT, these regulatory bodies integrate both technical proficiency and non-technical competencies—such as situational awareness, decision-making, and teamwork—into pilot training, thereby advancing aviation safety.

2.3.2 Distinctive Features

2.3.2.1 Characteristics of EASA

While international aviation authorities share the common objective of integrating EBT with digital technology, each organization adopts a distinct approach based on its regulatory philosophy and operational environment. EASA focuses on strengthening legal frameworks, FAA emphasizes flexible operational implementation, and CAA prioritizes non-technical competencies. These variations reflect the regional adaptation of ICAO standards.

2.3.2.2 Strengthening the Legal Framework under EASA

The EASA places significant emphasis on systematically integrating EBT and digital technology within a legal framework. EASA's Part-ORO regulations formally define digital training environments and establish explicit criteria for training organizations to implement EBT programs. For instance, EASA mandates that pilots complete essential training modules at least once every 12 months, with all training records maintained as digital logs for regulatory review. This legal foundation ensures that training outcomes derived from digital simulators are recognized as valid qualifications for pilot certification.

Additionally, EASA ensures consistency in digital EBT through its instructor standardization programs. Instructors must demonstrate proficiency in utilizing digital tools, such as simulator data analysis and VR-based training design, with periodic competency assessments conducted to maintain certification. For example, during an engine failure scenario, instructors leverage digital systems to analyze pilots' response data, ensuring objectivity in performance evaluation. This legal framework reinforces training quality across European airlines and flight training organizations, contributing to a reduction in aviation incidents—such as recent landing failures attributed to extreme weather conditions within the region.

2.3.2.3 Flexible Operations by the FAA

The FAA focuses on flexibly implementing EBT and digital technologies through Part 121 regulations. The FAA allows airlines to customize digital training programs based on their operational environment and characteristics, reflecting the diversity and scale of the U.S. aviation industry. For example, large carriers operate complex international routes, while low-cost carriers primarily operate short domestic flights; therefore, digital EBT is tailored to meet the specific needs of each airline. Airlines can incorporate risk factors frequently encountered in their operations, such as delays caused by airport congestion, into digital simulator training scenarios.

The FAA also provides flexibility in digital data analysis. Airlines can integrate flight operation data with simulator training data for in-house analysis, allowing for the optimization of training programs. For example, frequent system alerts on specific aircraft types can be analyzed through digital systems, leading to the design of specialized training scenarios for those aircraft. This flexibility demonstrates how the FAA's digital EBT has significantly contributed to reducing aviation safety incidents, such as emergency landings caused by weather anomalies, and differentiates itself with an approach that respects airline autonomy.

2.3.2.4 Emphasis on Non-Technical Skills by the CAA

The CAA of the United Kingdom, through CAP 737 regulations, utilizes EBT and digital technologies with a focus on enhancing pilots' non-technical skills. The CAA defines key competencies such as Situational Awareness, Decision-Making, and Teamwork, which are objectively assessed using digital tools. For example, digital Behavioral Indicators measure how pilots collaborate with colleagues during communication failure scenarios, and this is recorded and analyzed by digital systems.

The CAA's digital EBT prioritizes non-technical elements in scenario design for training. For instance, in simulating delayed landing scenarios due to adverse weather conditions, not only the pilots' technical maneuvering skills but also their communication and decision-making processes with the crew are tracked through digital data(Helmreich, 1999). This data is provided as feedback after the training, helping pilots improve their non-technical weaknesses. The CAA's approach has contributed to reducing aviation incidents in the UK, such as delays caused by human error, and emphasizes the impact of non-technical skills on safety.

III. Domestic Implementation of EBT and Digital Training

3.1 Problem Analysis

The domestic aviation training system still adheres to a traditional, theory-centric approach, with the implementation of EBT and digital technologies, as outlined by the ICAO, being in its infancy(Ahn and Hwang 2021). This lack of a robust digital EBT system became glaringly evident in the recent aviation safety incident, particularly the Jeju Air aircraft collision on December 29, 2024, at Muan International Airport, which resulted in the deaths of 179 out of 181 passengers. The absence of digital EBT is shown to have had a significant impact on safety. The recent aviation accident was largely attributed to the pilot's inadequate response to abnormal situations and insufficient training, raising the possibility that such an incident might have been prevented had EBT, enhanced by digital technology, been in place(Dekker, 2002). In this context, the domestic training system's issues can be concretized into three specific problems.

First, the lack of digital infrastructure is the most fundamental issue. The absence of modern simulators and data analysis systems severely limits the implementation of EBT-based practical training. For example, most domestic training institutions still use outdated simulators, and advanced equipment such as VR or AI-integrated systems are extremely rare. This inability to realistically simulate complex weather conditions or system failures makes it difficult to prepare pilots for various threats they may face during actual flight operations. The lack of a digital environment to train on weather deterioration and collision scenarios, as seen in the Muan accident, highlights the severity of this issue.

Second, the lack of digital proficiency among instructors is another obstacle to the introduction of EBT. Currently, domestic flight instructors are accustomed to traditional training methods and have limited experience with digital tools and the application of EBT. For instance, there is insufficient technical knowledge to analyze data generated from digital simulators or design VR-based training scenarios. This results in instructors being unable to provide effective, data-driven feedback and customized training, which diminishes the quality of training. In practice, when attempting to train for scenarios similar to the Muan accident in a digital environment, the expertise of the instructors is crucial. However, given the current state, such expertise is lacking.

Third, the absence of a structured data management system undermines the effectiveness of digital EBT. There is no systematic collection, analysis, or storage system for flight data, preventing the data-driven approach required by EBT from being implemented(Kim et al., 2020). For example, domestic airlines primarily use FDR data for accident investigations, but there is a lack of systems to link this data to training improvements. This leads to missed opportunities to analyze similar risk factors (e.g., collision during landing) and incorporate them into training after an incident like the Muan accident. Without a proper data management system, it becomes impossible to continuously update and ensure the quality of EBT, making it difficult to achieve long-term goals of enhancing aviation safety.

These issues illustrate that the domestic aviation training system fails to meet ICAO standards and is lagging behind in the digital transformation era. If these problems are not addressed, it will be challenging to respond effectively to current aviation safety threats.

3.2 Improvement Measures

3.2.1 Establishment of Digital Infrastructure

In order to successfully implement ICAO's EBT domestically, the establishment of digital infrastructure is essential.

First, the introduction of advanced simulators is urgent. Simulators integrated with VR technology realistically replicate complex flight environments, allowing pilots to safely train for situations such as weather anomalies, engine failures, and airport collisions(Koo and Lee, 2021). For instance, practicing low-visibility landing scenarios similar to those in aviation accidents using VR simulators can significantly enhance a pilot's response capabilities. To achieve this, it is necessary to deploy a minimum of 5 to 10 state-of-the-art simulators in major domestic training institutions, with plans for gradual expansion.

Second, there is a need to establish a data analysis system. A digital platform that analyzes flight data and training results in real-time will allow for objective tracking of pilot performance and support data-driven decision-making in EBT. For example, analyzing an airline's flight record data could identify frequent errors on specific aircraft types (e.g., malfunction of the automatic landing system) and incorporate these into training scenarios. This system should be cloud-based to facilitate data sharing between airlines and training institutions.

Third, strengthening cooperation between the government and private sector is essential. Establishing digital infrastructure requires significant initial investment; therefore, combining public funding with private technology to supply equipment to training institutions is crucial. For example, the government can provide financial support through institutions like the Aviation Safety Technology Institute, while forming partnerships with private companies (e.g., simulator manufacturers like CAE) to reduce costs and promote technology transfer. This collaboration will enable major training institutions to elevate their digital infrastructure to ICAO standard levels within 3 to 5 years.

3.2.2 Enhancement of Instructor's Digital Competency

The success of EBT largely depends on the competency of the instructors.

First, there is a need to develop a Digital EBT Instructor Training Program. This program should include the use of simulators, data analysis, and VR training design to prepare instructors to effectively conduct EBT in a digital environment. For example, instructors should undergo training where they analyze pilots' response times during landings using digital simulators and provide feedback based on these analyses.

Second, regular re-training should be conducted to maintain instructors' professionalism. As digital technologies and EBT trends evolve rapidly, re-training should be mandatory once or twice a year to ensure instructors stay up-to-date with the latest knowledge. For example, ICAO's latest EBT guidelines or new simulator features (e.g., AI-based scenario generation) should be included in the training curriculum. Aviation training experts can be invited, or overseas training programs can be implemented to provide instructors with international insights.

Third, an accreditation system should be introduced to ensure the quality of instructors. Instructors capable of conducting digital EBT should be granted official certification, which should be specified under the Aviation Safety Act. The certification criteria should include proficiency in the use of digital tools, a track record in EBT training design, and consistency in evaluations. For instance, instructors should prove at least 50 hours of digital simulator training experience to qualify for certification. This will standardize instructors' competencies and enhance the reliability of training.

3.2.3 Establishment of Legal Framework

A legal framework is necessary for the stable implementation of digital EBT.

First, the introduction of new legal provisions is essential. The Aviation Safety Act should be amended to include a clause stating, "Training institutions must operate EBT and digital data analysis systems, and must evaluate and improve the safety and effectiveness of pilot training." This clause will encourage training institutions to mandatorily adopt digital EBT and legally ensure compliance with ICAO standards.

Second, standards should be established for incorporating EBT results into qualification certification. Training performance data generated through digital EBT should be recognized for pilot license renewals or promotion requirements. For example, pilots who achieve a certain level of performance in specific scenarios (e.g., emergency landings) could be exempt from certain evaluations. This would allow digital EBT to harmonize with the existing qualification system, thereby strengthening safety from a practical standpoint.

Third, a regulatory oversight system must be established. The Ministry of Land, Infrastructure, and Transport(MOLIT) and the Aviation Safety Technology Institute should regularly inspect the operation of digital EBT and monitor compliance with legal requirements. For example, training institutions' data management systems and simulator operation status should be audited annually to maintain quality. This ensures that legal support leads to tangible safety improvements.

3.2.4 Data Management and Security

Systematic management of data generated during EBT training is essential.

First, the establishment of a data management system is critical. Flight data and training records should be stored in a standardized digital database, designed to facilitate easy retrieval and analysis(Kim et al., 2021). For example, a cloud-based system can allow all training institutions to centrally manage data and, when necessary, share it with airlines. This is particularly useful for analyzing data from incidents, such as the Muan accident, and reflecting it in training.

Second, strengthening security measures is important. In compliance with the Personal Information Protection Act, pilots' consent should be obtained during data collection, and encryption technology should be applied to prevent data leakage. For example, flight data should be anonymized before storage, and access should be restricted to training personnel and supervisory agencies. This ensures both data security and pilots' trust.

Third, regular reviews should be conducted to maintain data quality. The accuracy and utility of data should be reviewed at least once a year and updated as necessary. For example, the most recent accident data could be added, or old training records could be reanalyzed to align with the current operational environment. This will contribute to the continuous improvement of digital EBT and enhance safety.

3.3 Application of Digital EBT for Student Pilots

The introduction of Digital EBT at the student pilot stage allows them to gain practical experience from the outset. First, during the foundational stage, digital simulators are used to acquire basic flight skills. For example, students practice takeoff, landing, and simple weather changes (e.g., crosswinds) while improving operational accuracy through digital feedback. This helps students build technical foundations and become accustomed to the data-driven approach of EBT.

Second, in the intermediate stage, students enhance their practical competencies by engaging in data-driven, complex scenarios. For instance, they practice scenarios such as engine failure or communication breakdowns in a digital environment, and analyze the training data to evaluate their decision-making skills and teamwork. This prepares them to handle complex situations like the Muan Airport incident.

Third, in the advanced stage, comprehensive training simulating actual flight operations is conducted. Students experience scenarios involving weather anomalies, airport congestion, and system failures in digital simulators, while receiving real-time feedback to enhance their expertise. For example, if they achieve a success rate of over 90% in low-visibility landing training, it is used as qualification certification material. This strengthens the safety capabilities of student pilots and contributes to their development into safe and competent pilots in the future.

Ⅳ. Conclusion and Recommendations

4.1 Summary of Research

This study systematically presents measures to enhance aviation safety through the integrated use of EBT, an ICAO standard, and digital technologies. EBT, based on ICAO's Doc 9995, utilizes actual flight data and accident analysis to enhance training methods. When combined with digital technologies, the effectiveness and practicality of training are significantly improved. Digital data and advanced simulation technologies strengthen key elements of EBT, such as evaluation, maneuver training, and scenario-based training(Wise et al., 2009). These technologies support pilots in effectively responding to various crisis situations they may encounter in real flight environments. For example, digital simulators can safely reproduce complex scenarios such as weather anomalies or system failures, and FDA can identify individual weaknesses in pilots, providing customized feedback to improve them. This approach not only enhances pilots' technical skills but also boosts non-technical competencies, such as situational awareness, decision-making, and teamwork, ultimately improving aviation safety.

4.2 Implications and Recommendations

To apply digital EBT to the domestic aviation training system, several essential elements must be addressed. First, the establishment of digital infrastructure is urgent. Currently, domestic training institutions are unable to fully leverage the potential of EBT due to a lack of modern simulators and data analysis systems. For example, simulators integrated with VR technology can realistically simulate complex flight environments, but few institutions have implemented this technology. Second, enhancing instructors' digital capabilities is necessary. The effectiveness of EBT depends on how well instructors utilize digital tools, and therefore specialized training in simulator operation, data interpretation, and VR-based training design is essential. Third, legal support systems need to be refined. Specific provisions for the operation of digital EBT should be added to the aviation safety regulations (e.g., "Training institutions must evaluate the effectiveness of EBT using digital data analysis systems"), establishing a legal foundation for its implementation. Fourth, the systematization of data management is crucial. A standardized digital database for collecting, analyzing, and storing flight data and training results will support the continuous improvement and safety verification of EBT. When these elements are integrated, domestic aviation training will align with ICAO standards and transition to a system that can effectively improve aviation safety.

The introduction of digital EBT is not merely a technological innovation but could fundamentally transform aviation safety culture. It could directly contribute to preventing tragic incidents, such as the Jeju Air crash at Muan International Airport on December 29, 2024. Had digital EBT been in place, pilots would have likely undergone repeated training in a similar collision scenario using digital simulators and strengthened their response capabilities through real-time data feedback. Moreover, digital EBT could be used to incorporate post-accident analysis data into training, preventing the recurrence of similar incidents(Ahn et al., 2020). This would act as a practical safety net, protecting the lives of passengers and crew members, while enhancing the reliability and competitiveness of the domestic aviation industry.

For this to be realized, active support from both the government and the aviation industry is essential. The government should lead the investment of public funds in building digital infrastructure and legal adjustments. For example, collaborating with simulator manufacturers could reduce costs and expand equipment distribution to training institutions. The aviation industry should strengthen cooperation between airlines and training institutions to share operational data on digital EBT and continuously improve training quality based on this data. Such cooperation will ensure that domestic aviation training meets ICAO standards and aligns with global aviation safety norms. Furthermore, applying digital EBT across all stages, from student pilots to experienced pilots, will establish a long-term, safety-centered aviation culture.

However, this study has several limitations. First, there is a lack of cost analysis for the implementation of digital EBT. The initial installation costs of advanced simulators and data systems, maintenance costs, and instructor training expenses may pose significant financial burdens, and a detailed economic feasibility assessment is necessary. Second, there is limited in-depth discussion regarding the feasibility of implementation. Factors such as the level of infrastructure at domestic training institutions, the readiness of the aviation industry for digital transformation, and the speed of legal adjustments are variables that need empirical data. These limitations somewhat restrict the practical applicability of the research and should be addressed in future studies.

In conclusion, this study emphasizes that the integration of ICAO-standard EBT with digital technologies is an inevitable direction for enhancing recent aviation safety. Digital EBT presents a new paradigm for pilot training and can help the domestic aviation industry meet international safety standards, contributing to the prevention of tragedies like the Muan accident. If the government and the aviation industry actively collaborate to promote this, a safe and reliable aviation environment suited to the digital transformation era can be established.

Acknowledgments

This research was supported by the Korea National University of Transportation in 2025.

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