International Journal of Transport Development and Integration
Vol. 9, No. 3, September, 2025, pp. 485-492
Journal homepage: http://iieta.org/journals/ijtdi

Enhancing Aviation Cadet Competencies Through Simulator Based Training: A Study Using the ADDIE Model and Importance Performance Analysis

Hadi Prayitno[1,2*], Ekohariadi[3], Mochamad Cholik[4], Ratna Suhartini[1], Arie Wardhono[5]

[1] Vocational Education Department, Universitas Negeri Surabaya, Surabaya 60231, Indonesia
[2] Aircraft Engineering Department, Politeknik Penerbangan Surabaya, Surabaya 60236, Indonesia
[3] Informatics Department, Universitas Negeri Surabaya, Surabaya 60231, Indonesia
[4] Mechanical Engineering Department, Universitas Negeri Surabaya, Surabaya 60231, Indonesia
[5] Civil Engineering Department, Universitas Negeri Surabaya, Surabaya 60231, Indonesia

Corresponding Author Email: hadi.22018@mhs.unesa.ac.id

https://doi.org/10.18280/ijtdi.090303

Received: 5 May 2025
Revised: 12 June 2025
Accepted: 20 June 2025
Available online: 30 September 2025

Keywords:
ADDIE model, decision making, flight performance, flight simulator, Redbird FMX1000, safety awareness

ABSTRACT

This study developed and evaluated a simulator-based instructional model to enhance cadet pilot competencies in safety awareness, decision making, and flight performance. Using the ADDIE instructional design model, the research involved 60 cadets from the Indonesian Aviation Academy Banyuwangi. A pre-test/post-test design was employed, with data analyzed using paired sample t-tests. The SIM-FLIGHT model was implemented through structured modules, scenario-based assessments, and instructor guidelines using the Redbird FMX1000 flight simulator. The results showed significant improvements in all competency areas: safety awareness increased by 24.70 points, decision making by 24.62 points, and flight performance by 54.22 points (all $p < 0.001$). Importance-Performance Analysis (IPA) confirmed that all competencies fell into the high-importance/high-performance quadrant, indicating alignment between instructional goals and outcomes. These findings highlight the effectiveness of integrating simulation with structured instructional models. Practically, the model offers a scalable framework for aviation institutions to enhance competency-based training through data-driven, simulation-integrated approaches.

1. INTRODUCTION

Aviation remains one of the most safety-critical industries, where pilot competence is directly tied to operational safety. Modern pilot training is no longer confined to in-aircraft instruction; it now incorporates high-fidelity simulation tools that enable cadets to experience realistic flight scenarios without the risks and costs associated with real aircraft operations [1, 2].

In this context, flight simulators have emerged as essential components of pilot training systems worldwide. They allow for repeated practice, controlled exposure to emergencies, and measurable skill acquisition [3].

The effectiveness of these tools, however, depends not only on the technology itself but also on the pedagogical model that governs their implementation [4].

In Indonesia, the integration of flight simulation into pilot education is still evolving. While several government and private aviation academies have adopted simulation-based training, the level of integration and instructional rigor varies significantly [5].

A 2023 internal review by the Indonesian Aviation Training Authority revealed that fewer than 30% of flight schools nationwide utilize standardized simulator-based assessment models, and even fewer align their simulator usage with competency-based training frameworks such as the Competency-Based Training and Assessment (CBTA) guidelines recommended by the International Civil Aviation Organization (ICAO). This limited adoption suggests a significant gap between international best practices and local implementation [6, 7].

Furthermore, existing academic studies on flight simulation in Indonesia tend to focus on conceptual analyses or practitioner observations, offering little in the way of empirical evidence. Most research lacks robust design frameworks and quantifiable outcomes [8].

Critical variables such as safety awareness (SA), decision making (DM), and flight performance (FP) are rarely assessed in a structured, measurable way. For example, while the Redbird FMX1000 is commonly used in simulation labs, its instructional deployment is often limited to technical familiarization rather than systematic competency development [9].

Evaluation tools are generally observational and subjective, with limited use of rubrics or validated performance metrics [10].

This disconnect highlights a core issue: The underutilization of simulator technology is not due to the tools themselves but rather the absence of a structured instructional model that links simulator use to measurable learning outcomes. There is a clear need for a pedagogically sound framework that integrates simulator-based learning with objective evaluation criteria, aligned with both regulatory standards and learning theories [11].

To address this gap, instructional design models such as Analysis, Design, Development, Implementation, and Evaluation (ADDIE) can offer a structured approach to developing simulator-based training programs. The ADDIE model is widely recognized in the field of instructional systems design and provides a systematic process for developing, testing, and refining educational programs. By applying ADDIE, it is possible to create a comprehensive flight training model that not only incorporates technical simulation but also targets specific learning outcomes and includes tools for rigorous assessment [12, 13].

This study aims to develop and evaluate a practical flight training model termed SIM-FLIGHT based on the ADDIE instructional framework. The model is designed to systematically enhance cadet pilot competencies in three core areas: safety awareness, decision making, and flight performance [14].

The model includes instructional modules, instructor guides, assessment rubrics, and scenario-based training procedures. It is implemented using the Redbird FMX1000 simulator, and its effectiveness is evaluated using pre- and post-test assessments analyzed via paired sample t-tests [9].

Additionally, the Importance-Performance Analysis (IPA) method is employed to determine how well the model aligns with targeted competencies and learner expectations [15].

This research contributes to the growing field of aviation education by providing a replicable and data-driven instructional model. It offers aviation academies a practical tool for aligning simulation technology with competency-based training outcomes, thereby bridging the gap between theoretical knowledge and applied skills in the context of Indonesian pilot education [9].

2. LITERATURE REVIEW

2.1 The role of flight simulators in pilot training

Flight simulators have become an integral component of modern pilot training, serving as instructional tools capable of replicating real-world flight environments in a safe and controlled setting. These devices enable trainees to practice a wide range of scenarios, including emergency conditions that are otherwise difficult to reproduce in actual flights.

The primary goal of such training is to minimize operational risk while enhancing the operational proficiency of pilot candidates. In Indonesia, advanced flight simulators such as the Redbird FMX1000 are employed in institutions like the Indonesian Aviation Academy in Banyuwangi [9].

This simulator features a 200° visual display, a three-axis motion platform (yaw, pitch, roll), and a complete avionics suite, significantly improving cadets' situational awareness [16, 17]. Beyond improving cost-efficiency and safety, simulators contribute meaningfully to the mastery of Standard Operating Procedures (SOPs), crisis decision-making, and the development of both basic and advanced manoeuvring skills [18, 19].

Furthermore, within the context of licensing programs, flight simulators are formally recognized by international and national regulatory frameworks, including ICAO standards and Indonesia's CASR Part 141, as partial substitutes for actual flight hours [7, 10].

2.2 Instructional design in aviation education

Effective instructional design is essential to optimizing simulation-based training. The ADDIE model comprising five phases—Analysis, Design, Development, Implementation, and Evaluation—provides a systematic framework for the development of simulation-based instructional programs [8, 13, 20].

Within the context of aviation cadet training, implementation of the ADDIE model has demonstrated its efficacy in facilitating the structured transfer of knowledge and skills. Specifically, the analysis phase identifies learning needs; the design phase creates instructional scenarios; the development phase produces digital content and standard procedures; the implementation phase integrates these materials into formal training; and the evaluation phase assesses their impact on trainee competency.

The ADDIE model also enables personalized, performance-based learning while supporting instructors in managing the simulator-based training process in a more structured and coherent manner [21].

2.3 Competency domains in pilot education

Pilot education emphasizes mastery across three core competency domains: safety awareness, decision making, and flight performance [22]. Safety awareness encompasses an understanding of safety procedures and the ability to proactively recognize and respond to potential risks [23].

This is assessed through loading (workload data) and logging (behavioural records during simulation) metrics [24]. Decision making involves the ability to respond swiftly and appropriately to emergency situations, assessed via indicators such as response, procedural skills, attitude management, stress management, and critical action [25]. Decision-making models like FOR-DEC and T-DODAR serve as standardized guidance in pilot training.

Flight performance is a composite measure of technical proficiency, procedural knowledge, and professional attitude [26]. The performance is evaluated through indicators such as skill, knowledge, and attitude [16].

The measurement of these competencies is crucial not only for assessing the cadet's readiness but also for supporting the pilot licensing and certification process as mandated under CASR Parts 61 and 141.

2.4 IPA in education

IPA is an analytical tool used to identify gaps between perceived importance and actual performance of service or training attributes. In aviation education, IPA is employed to evaluate the effectiveness of simulator training in developing pilot competencies [15].

IPA is typically conducted by plotting cadets' perceptions along two dimensions: importance and performance [16]. The resulting Cartesian matrix divides attributes into four quadrants, indicating which should be prioritized, maintained, minimized, or reconsidered.

In this study, IPA is applied to assess dimensions such as safety awareness, decision making, and flight performance, allowing for the identification of specific areas needing improvement. The application of IPA contributes strategically to the curriculum design and the development of simulation-based training modules that are more targeted and responsive to learning needs [24, 27].

2.5 Gaps in existing research

Despite the widespread use of flight simulators in aviation education, several notable research gaps remain, including a lack of empirical studies evaluating the structured impact of flight simulators on pilot competency development, particularly through pedagogical variables [28]. Absence of standardized assessment models for objectively measuring the effectiveness of simulator-based training, especially regarding the Redbird FMX1000 [29].

Current assessments tend to rely on subjective and simplistic evaluation forms. Insufficient integration between simulator technologies and adaptive learning systems or data-driven assessment frameworks limits the availability of valid and reliable feedback for learning outcomes.

Limited exploration of ADDIE-based instructional design specifically in simulator-based aviation training, particularly within vocational education contexts in Indonesia. Addressing these gaps is critical not only for developing valid assessment tools and effective training designs, but also for contributing to the academic discourse on simulation-based pilot education [13].

3. METHODOLOGY

3.1 Research design and sampling

This study employed a Research and Development (R&D) approach using the ADDIE instructional design framework: Analysis, Design, Development, Implementation, and Evaluation. The model was applied to the development of a simulator-based flight training intervention named SIM-FLIGHT. The training focused on enhancing cadet competencies in safety awareness, decision making, and flight performance [13, 30].

The sampling method used was total sampling, involving 60 cadets enrolled in the Private Pilot License (PPL) program at the Indonesian Aviation Academy Banyuwangi. Total sampling was selected due to the relatively small and homogeneous target population; all cadets had completed ground school and were scheduled for pre-solo flight simulation sessions [9].

This ensured that all participants had comparable prior exposure to theoretical training and met the same institutional flight readiness criteria. The use of total sampling helped maximize data reliability and reduced variability due to differences in training stages or curricula [31].

3.2 Instrument development and validation

The research instruments included: Assessment rubrics for each competency (SA, DM, FP), Scenario-based flight simulation tasks, Instructor observation sheets, and Self-assessment questionnaires for IPA.

Instrument development was based on ICAO CBTA guidelines, FAA standards for scenario-based training, and validated indicators from previous aviation education studies. A pilot test was conducted with 10 cadets from a different cohort to examine instrument clarity, content relevance, and time effectiveness. Revisions were made based on pilot feedback and expert input.

The final instruments underwent content validation by three aviation education experts and two experienced flight instructors. The Content Validity Index (CVI) for all items exceeded 0.85, indicating strong relevance. Cronbach's Alpha values for internal consistency were 0.88 (SA), 0.85 (DM), and 0.91 (FP), confirming reliability.

3.3 Training intervention and ADDIE implementation

The SIM-FLIGHT model was implemented over six weeks, with training sessions scheduled three times a week. Each session lasted approximately 90 minutes, divided into briefing, simulation execution, and debriefing.

The implementation of the ADDIE model phases is presented systematically, as illustrated in Figure 1.

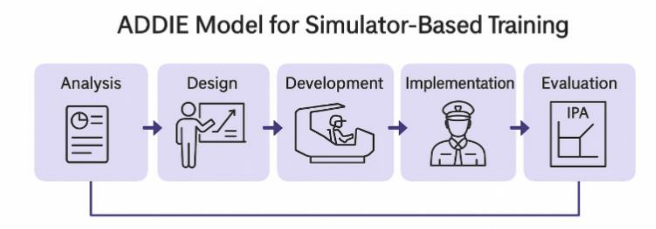

Figure 1. ADDIE model

The ADDIE development process was implemented as:

Analysis (Week 1): A needs analysis was conducted through document review (Training Course Outline), instructor interviews, and cadet performance records. Competency gaps were identified in SA, DM, and FP.

Design (Week 2): Training objectives were aligned with ICAO's competency frameworks. Modules were designed for three learning domains (cognitive, psychomotor, affective) with scenario-based exercises mapped to each competency.

Development (Weeks 2–3): Learning materials (briefing sheets, flight checklists, rubrics, instructor guides) were created and digitized. Redbird FMX1000 scenarios were programmed to simulate VFR conditions and emergency responses.

Implementation (Weeks 4–5): The SIM-FLIGHT program was delivered by certified flight instructors. Each cadet completed six flight simulation sessions, with real-time instructor evaluation and post-flight debriefings using standardized rubrics.

Evaluation (Week 6): Pre-tests and post-tests were conducted using the same simulator-based tasks. Paired sample t-tests were used to assess learning gains. IPA questionnaires were administered post-intervention to evaluate cadet perceptions of performance versus instructional importance [13].

4. RESULTS AND DISCUSSION

4.1 Results

The analysis of pre- and post-test data from 60 cadets revealed statistically significant improvements across all three assessed variables: safety awareness, decision making, and flight performance.

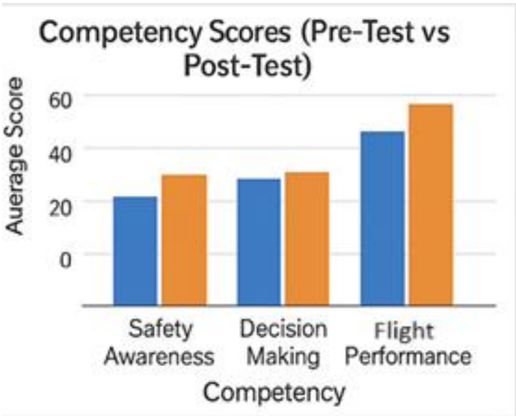

Figure 2. Pre- and post-test competency score

Figure 2 illustrates a clear improvement in the average scores across all assessed competency domains when comparing pre-test and post-test results, namely safety awareness, decision making, and flight performance, following the implementation of the training intervention. Specifically, the safety awareness score increased from approximately 22 to 33, decision making rose from 28 to 36, and the most substantial improvement was observed in flight performance, which increased from around 43 to nearly 58.

These findings indicate that the training program effectively enhanced participants' knowledge and skills, particularly in the area of flight performance, which demonstrated the greatest score improvement. This outcome reflects the efficacy of the training methods employed and suggests that the intervention is a reliable strategy for professional competency development [14].

However, the relatively modest gain in decision making competency highlights a potential area for further instructional refinement. Overall, these results underscore the importance of data-driven evaluation in designing and optimizing competency-based training programs.

Figure 3. Performance gap

Figure 3 presents the performance gap across three critical competency areas: safety awareness, decision making, and flight performance, by comparing pre-test and post-test scores. The analysis reveals a marked variation in the magnitude of improvement across these competencies.

The most significant improvement was observed in the flight performance domain, where participants experienced a substantial increase of 54.22 points. This result underscores the considerable effectiveness of the training intervention in enhancing participants' operational capabilities in flight performance. The magnitude of this improvement may be attributed to a strong alignment between the training content and its practical application, as well as an initially lower baseline competence, which allowed for a more substantial measurable gain [32]. In contrast, the competencies of safety awareness and decision making demonstrated more modest gains, with increases of 24.70 and 24.62 points, respectively. These relatively smaller improvements may reflect a ceiling effect, resulting from a higher level of pre-existing knowledge or skills in these areas, or could be indicative of limitations in the instructional methods used. The similarity in the magnitude of these gains suggests that, while the training did contribute to competency enhancement, its impact on safety awareness and decision making was less pronounced than in the flight performance domain. The performance gap, as shown by the average score increase from pre-test to post-test, illustrates that flight performance experienced the highest gain (+54.22 points), while safety awareness and decision making showed more modest increases (+24.70 and +24.62 points, respectively). These findings indicate that simulator-based learning had the most substantial impact on developing technical flight skills, while also leading to meaningful improvements in cadets' cognitive and decision-making abilities. To provide a more comprehensive evaluation of the training effectiveness, an IPA was conducted, and its results are presented in Figure 4.

These findings highlight the importance of implementing differentiated instructional strategies that are responsive to the distinct characteristics and learning needs of each competency area. For competencies demonstrating limited improvement, such as decision making, it is recommended that future training programs incorporate more interactive, experiential, or scenario-based learning approaches to foster deeper cognitive engagement and practical skill development. Identifying such performance gaps through empirical data analysis is critical for the iterative refinement of training interventions, thereby ensuring that all dimensions of professional competence are effectively addressed and aligned with safety and performance standards.

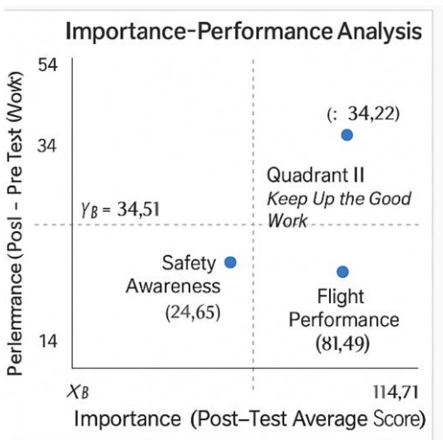

Figure 4. IPA

Based on the results of the IPA, it can be concluded that among the three assessed aspects, only one falls into Quadrant II—classified as the "Keep Up the Good Work" area, indicating that this aspect has both high importance (114.71) and relatively good performance (34.22). This suggests that the quality of training in this area should be maintained [15].

In contrast, the flight performance aspect is positioned in Quadrant IV, signifying high importance (81.49) but below-average performance (less than 34.51). This discrepancy highlights it as a primary area for improvement, warranting a review of training methods or enhancement of instructional strategies.

Meanwhile, safety awareness is located in Quadrant III, with both importance and performance scores being relatively low (24.65). This suggests that the aspect is not currently a focus of participant attention and may be considered a lower priority in terms of program enhancement.

These findings emphasize the necessity of categorizing training components to optimize resource allocation and improve the overall effectiveness of competency development initiatives.

The horizontal axis represents the post-test importance as perceived by the cadets, while the vertical axis reflects the performance improvement. All three variables were located in Quadrant II, labeled "Keep Up the Good Work," indicating both high importance and strong flight performance.

This placement reflects the success of the instructional design in aligning with learner needs and delivering measurable outcomes [33].

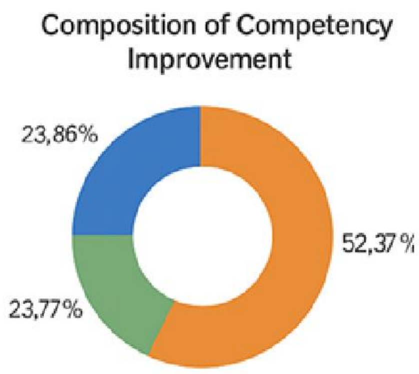

Figure 5. Composition of competency improvement

Figure 5 illustrates the proportional composition of competency improvement across three evaluated domains: safety awareness, decision making, and flight performance. The results indicate that flight performance constituted the largest share of the total observed improvement, accounting for 52.37% of the overall competency gains.

This finding reinforces earlier evidence demonstrating that flight performance experienced the greatest absolute increase, suggesting that the training intervention was particularly effective in this area.

By contrast, safety awareness and decision making contributed almost equally to the overall improvement, representing 23.86% and 23.77%, respectively. These comparatively smaller proportions suggest that, although participants exhibited progress in these domains, the magnitude of development was both quantitatively and relatively less substantial. Several potential factors may underlie this outcome, including higher baseline proficiency, limited instructional emphasis, or reduced perceived applicability of the material during the training process.

The predominance of flight performance improvement highlights the critical importance of aligning training programs with practical, outcome-driven objectives. While such alignment appears to have yielded substantial benefits for flight performance, the modest and parallel gains observed in safety awareness and decision making suggest a need to reevaluate the pedagogical approaches employed for these competencies.

To enhance learning outcomes, particularly in cognitive and attitudinal domains, future instructional designs should consider integrating more interactive methodologies, such as scenario-based exercises, immersive simulations, or structured reflective activities. These techniques can foster deeper engagement and promote the development of complex decision-making skills.

From a broader competency development perspective, the proportional data offer not only a measure of distributional change across domains but also serve as a valuable diagnostic tool for identifying instructional gaps. Such insights are particularly vital in performance-oriented training contexts, especially within high-stakes or safety-critical environments where balanced and comprehensive competency enhancement is essential to achieving operational reliability and excellence.

Figure 5 presents the composition of competency improvement. Flight Performance contributed to 52.37% of the total competency gain, confirming its dominant role in the training results. Safety awareness (23.86%) and decision making (23.77%) followed closely, with almost equal contributions, underscoring balanced growth in both technical and non-technical skills.

These findings affirm that the instructional model built around the Redbird FMX1000 is highly effective in supporting multidimensional pilot training and aligns with the principles of competency-based education in aviation [34].

4.2 Discussion

The results of this study confirm that the SIM-FLIGHT model, developed using the ADDIE instructional design framework, produced statistically significant improvements across all three core competency areas: safety awareness, decision making, and flight performance. Inferential statistical analysis using Paired Sample t-tests demonstrated p-values < 0.001 for all indicators, confirming that the observed improvements were statistically significant and not due to chance. These findings validate the effectiveness of structured, simulation-based instructional models in pilot education, aligning with prior research that has emphasized the value of simulations in enhancing pilot competencies. Flight performance exhibited the highest absolute improvement, with a gain of 54.22 points (from 66.2 to 81.5), compared to SA (24.6 points) and DM (24.7 points). This pattern invites deeper theoretical reflection. From a cognitive learning perspective, flight performance is primarily influenced by procedural memory and psychomotor learning, which are particularly responsive to repetitive, feedback-rich environments such as flight simulators. Cognitive Load Theory suggests that simulation environments reduce extraneous cognitive load and promote germane processing, thereby facilitating the automation of motor skills.

In contrast, decision making and safety awareness are complex non-technical skills that depend more on higher-order cognition, such as situational analysis, probabilistic reasoning, and affective regulation. These domains are less responsive to short-term simulation training unless accompanied by metacognitive reflection or decision-making interventions, such as scenario debriefings or guided discussions. This may explain the relatively smaller, but still significant, improvements in DM and SA. These results are consistent with previous studies indicating that psychomotor skills tend to develop more rapidly than cognitive-judgment abilities in simulation-based aviation training.

Importantly, the findings extend previous research by providing empirical validation of simulator training effectiveness within a fully implemented ADDIE framework something that many prior studies lacked. Furthermore, the inclusion of IPA provided additional insights into cadet perceptions. All competency areas were positioned in the high-importance/high-performance quadrant, suggesting strong alignment between instructional objectives and learner outcomes. This supports the construct validity of the model and affirms its potential for scalability across aviation training institutions [15].

Theoretically, this study reinforces constructivist learning principles, which argue that knowledge and skill development are optimized when learners are actively engaged in context-rich environments. The simulator serves as a platform for cognitive apprenticeship, allowing cadets to build mental models through iterative practice, immediate feedback, and reflective activities. Moreover, the ADDIE model served not just as a planning framework, but also as a pedagogical control system, ensuring that each phase of the instructional process from needs analysis to evaluation was explicitly aligned with learning objectives and assessment strategies. The consistent improvement across all cadets suggests that the SIM-FLIGHT model adheres to principles of Universal Design for Learning (UDL), offering multi-modal learning opportunities that accommodate varying learner needs and cognitive styles [35].

5. CONCLUSION

This study developed and validated the SIM-FLIGHT model, a simulator-based flight training framework grounded in the ADDIE instructional design approach, to enhance cadet pilot competencies in safety awareness, decision-making, and flight performance. The model demonstrated substantial improvements in all three assessed competencies, with safety awareness increasing by 24.70 points, decision-making by 24.62 points, and flight performance by 54.22 points, all with p-values < 0.001, confirming the model's effectiveness in enhancing pilot training outcomes. However, the study acknowledges several limitations, including the absence of a control group and the limited scope of implementation within a single institution, which may impact the generalizability of the findings. Additionally, the study was conducted using the Redbird FMX1000 simulator, which may limit the applicability of the results to other simulator platforms. Despite these limitations, the SIM-FLIGHT model offers a highly adaptable, structured framework that can be implemented across various flight simulators and training institutions, particularly those following ICAO's CBTA guidelines. This positions the model as a scalable tool for improving aviation training, particularly in Southeast Asia and other developing regions. Future research should focus on validating the model through comparative studies with control groups, longitudinal assessments of competency retention, and exploring the integration of decision-making reflection tools to further enhance non-technical skills development. The SIM-FLIGHT model has the potential to significantly advance competency-based aviation education globally, providing a replicable, data-driven framework for simulator-integrated training that bridges the gap between theoretical learning and real-world flight performance.

ACKNOWLEDGMENT

The authors would like to express their sincere gratitude to the State University of Surabaya, Aviation Polytechnic of Surabaya, and the Indonesian Aviation Academy in Banyuwangi for their financial support and assistance throughout the course of this research.

REFERENCES

[1] Borghini, G., Ronca, V., Giorgi, A., Aricò, P., et al. (2024). Reducing flight upset risk and startle response: A study of the wake vortex alert with licensed commercial pilots. Brain Research Bulletin, 215: 111020. https://doi.org/10.1016/j.brainresbull.2024.111020

[2] Brennan, E.S., Rehman, U., Sarwar, M.S., Bekker, K.A., Cowen, J., Bekker, J., Brennan, P.A. (2025). Human factors application, decision making, team working and leadership in Surgical Oncology. European Journal of Surgical Oncology, 51(6): 109679. https://doi.org/10.1016/J.EJSO.2025.109679

[3] Chen, J., Chen, A., Jiang, B., Zhang, X. (2024). Physiological records-based situation awareness evaluation under aviation context: A comparative analysis. Heliyon, 10(5): e26409. https://doi.org/10.1016/J.HELIYON.2024.E26409

[4] Chen, K.J., Shin, J.J., Chu, H.L., Chen, Y.L., Chu, C.H., Huang, Y.Y., Lee, Y.J. (2025). Training and dashboard design: Impact on operator performance and mental workload for flight safety. Safety Science, 181(101): 106700. https://doi.org/10.1016/j.ssci.2024.106700

[5] Cherng, C.F.G., Sher, J.S., Chu, H., Yu, L. (2022). The relationship between civil pilots' resilience, psychological well-being and work performance. Transportation Research Procedia, 66: 16-25. https://doi.org/10.1016/j.trpro.2022.12.003

[6] Choi, J.K. (2022). The enhancing error management of pilot and line operation safety audit. The Korean Journal of Aerospace and Environmental Medicine, 32(2): 44-49. https://doi.org/10.46246/KJASEM.220015

[7] Dapica, R., Hernández, A., Peinado, F. (2022). Who trains the trainers? Gamification of flight instructor learning in evidence-based training scenarios. Entertainment Computing, 43: 100510. https://doi.org/10.1016/j.entcom.2022.100510

[8] Darses, F., Bernier, M., Berthelot, V., Fornette, M.P., Launay, Y., Dozias, B., Chastres, V., Fournier, J. (2023). Effects of mindfulness training on decision-making in critical and high-demand situations: A pilot study in combat aviation. Safety Science, 166: 106204. https://doi.org/10.1016/j.ssci.2023.106204

[9] Dillman, B., Ziakkas, D., Cutter, J. (2022). Selection and implementation of evidence based safety performance indicators in aviation training. Safety Management and Human Factors, 64: 63-69. https://doi.org/10.54941/ahfe1002629

[10] Ding, S., Hu, L., Pan, X., Zuo, D., Sun, L. (2025). Assessing human situation awareness reliability considering fatigue and mood using EEG data: A Bayesian neural network-Bayesian network approach. Reliability Engineering and System Safety, 260: 110962. https://doi.org/10.1016/j.ress.2025.110962

[11] Dožić, S. (2019). Multi-criteria decision making methods: Application in the aviation industry. Journal of Air Transport Management, 79: 101683. https://doi.org/10.1016/J.JAIRTRAMAN.2019.101683

[12] Gao, S., Bai, Y., Hong, R., Wang, L. (2025). Behavioral and psychophysiological responses of initial pilots in collaboration with an experienced but risky captain: A flight-simulation study based on the social facilitation. Safety Science, 187(2898): 106858. https://doi.org/10.1016/j.ssci.2025.106858

[13] Ghaderi, A., Saghafi, F. (2024). Enhancing pilot vigilance assessment: The role of flight data and continuous performance test in detecting random attention loss in short IFR flights. Journal of Air Transport Management, 120: 102673. https://doi.org/10.1016/j.jairtraman.2024.102673

[14] Gogalniceanu, P., Kunduzi, B., Ruckley, C., Scripariu, D.V., Kessaris, N., Calder, F., Sevdalis, N., Mamode, N. (2022). Crisis recovery in surgery: Error management and problem solving in safety-critical situations. Surgery, 172(2): 537-545. https://doi.org/10.1016/J.SURG.2022.03.007

[15] Harahap, M.H., Siregar, H., Rustiadi, E., Pravitasari, A.E. (2025). The impact of regional educational development policies on poverty reduction in North Sumatra Province. International Journal of Sustainable Development and Planning, 20(3): 1091-1102. https://doi.org/10.18280/ijsdp.200315

[16] Hariri, A., Parjan, Rubiono, G., Cahyo, D.H. (2022). Situational awareness training evaluation with computer based test for pilot cadet. World Journal of Vocational Education and Training, 4(1): 1-9. https://doi.org/10.18488/119.v4i1.3026

[17] Huttunen, K., Keränen, H., Väyrynen, E., Pääkkönen, R., Leino, T. (2011). Effect of cognitive load on speech prosody in aviation: Evidence from military simulator flights. Applied Ergonomics, 42(2): 348-357. https://doi.org/10.1016/j.apergo.2010.08.005

[18] Islam, M.A., Ali, M.M.N., Benitez, I.B., Sidi Habib, S., Jamal, T., Flah, A., Blazek, V., El-Bayeh, C.Z. (2025). A comprehensive evaluation of photovoltaic simulation software: A decision-making approach using Analytic Hierarchy Process and performance analysis. Energy Strategy Reviews, 58: 101663. https://doi.org/10.1016/J.ESR.2025.101663

[19] Janovec, M., Čerňan, J., Novák, A. (2022). Design of construction and instrumentation of the Zlín aircraft simulator. Transportation Research Procedia, 59: 46-56. https://doi.org/10.1016/j.trpro.2021.11.096

[20] Konrad, G., Khatwa, R., Feyereisen, T., Kemp, A. (2022). Development of a flight deck human factors design and certification competency taxonomy: Preliminary findings. Transportation Research Procedia, 66: 279-291. https://doi.org/10.1016/j.trpro.2022.12.028

[21] Wang, L., Yin, B.Y., Zhu, M.W., Hao, S. (2024). 3D image modeling and visual presentation technologies for education. Traitement du Signal, 41(2): 979-987. https://doi.org/10.18280/ts.410238

[22] Loft, S., Tatasciore, M., Visser, T. (2023). Managing workload, performance, and situation awareness in aviation systems. In Human Factors in Aviation and Aerospace (Third Edition). Academic Press, pp. 171-197. https://doi.org/10.1016/B978-0-12-420139-2.00018-6

[23] Martín-Lammerding, D., Astrain, J.J., Córdoba, A., Villadangos, J. (2023). An ontology-based system to avoid UAS flight conflicts and collisions in dense traffic scenarios. Expert Systems with Applications, 215: 119027. https://doi.org/10.1016/j.eswa.2022.119027

[24] Matas-Monroy, J.H., Martín, J.C., Román, C. (2025). An importance-performance analysis of public transport to the university campus based on best-worst scaling. Research in Transportation Economics, 109: 101519. https://doi.org/10.1016/J.RETREC.2025.101519

[25] Nevzorov, R. (2021). Quality management of ground training of future pilots in the conditions of modern educational space in Ukraine. Economics & Education, 6(2): 90-94. https://doi.org/10.30525/2500-946x/2021-2-16

[26] O'Hare, D. (2024). Effects of distance flown on pilot decision making in continued flight into deteriorating weather conditions. Journal of Safety Research, 88: 336-343. https://doi.org/10.1016/J.JSR.2023.11.020

[27] Orji, I.J., Ojadi, F., Okwara, U.K. (2022). Assessing the pre-conditions for the pedagogical use of digital tools in the Nigerian higher education sector. The International Journal of Management Education, 20(2): 100626. https://doi.org/10.1016/J.IJME.2022.100626

[28] Patel, S.R., Margolies, P.J., Covell, N.H., Lipscomb, C., Dixon, L.B. (2018). Using instructional design, analyze, design, develop, implement, and evaluate, to develop e-learning modules to disseminate supported employment for community behavioral health treatment programs in New York State. Frontiers in Public Health, 6: 113. https://doi.org/10.3389/fpubh.2018.00113

[29] Prayitno, H., Ekohariadi, Cholik, M., Anifah, L., Wardhono, A., Wicaksono, P. (2024). Improving pilot competence through flying practice learning using flight simulator at the Indonesia Civil Pilot Academy of Banyuwangi. Journal of Law and Sustainable Development, 12(1): e2426. https://doi.org/https://doi.org/10.55908/sdgs.v12i1.2426

[30] Prayitno, H., Ekohariadi, Cholik, M., Suprianto, B., Qiram, I. (2023). Impact of flight simulator training on enhancing situational awareness among aviation vocational education cadets. In 2023 International Conference of Computer Science and Information Technology (ICOSNIKOM), Binjia, Indonesia, pp. 1-6. https://doi.org/10.1109/ICoSNIKOM60230.2023.10364549

[31] Sari, Y.A., Indrawan, R.S., Rifai, A.I., Khairul, M., Mohd, A. (2025). A bibliometric review of design and performance. International Journal of Transport Development and Integration, 9(1): 27-37.

[32] Van Benthem, K., Herdman, C.M. (2020). The importance of domain-dependent cognitive factors in GA safety: Predicting critical incidents with prospective memory, situation awareness, and pilot attributes. Safety Science, 130: 104892. https://doi.org/10.1016/j.ssci.2020.104892

[33] Veras Neto, C.R., Rose, R.L., Thomas, J. (2024). Application of causal analysis based on systems theory (CAST) to regulatory decision-making: A case study of

the Sikorsky S92A. Aerospace Science and Technology, 155(P3): 109708. https://doi.org/10.1016/j.ast.2024.109708

[34] Vidal Rosas, E.E., Fernández, C.G. (2022). Pedagogical framework to develop interactive virtual tools for the teaching and learning of dynamic systems in Control Engineering. IFAC-PapersOnLine, 55(17): 218-223. https://doi.org/10.1016/J.IFACOL.2022.09.282

[35] Ziakkas, D., Michael, W.S., Pechlivanis, K. (2022). The implementation of competency-based training and assessment (CBTA) framework in aviation manpower planning. Transportation Research Procedia, 66: 226-239. https://doi.org/10.1016/j.trpro.2022.12.023