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Enhancing Pilot Skills: The Effectiveness of Preflight Simulation Training

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Abstract

This study examined the perceived effectiveness of pre-flight simulation training in developing the competencies of student pilots at Indiana Aerospace University, particularly in relation to flight readiness, knowledge of aircraft systems and procedures, decision-making, reaction time, situational awareness, multitasking, maneuver proficiency, safety, error reduction, and preparation for actual flight conditions. The study was informed by experiential learning, cognitive load, behavioral learning, situated learning, schema, deliberate practice, and transfer-of-learning perspectives that explain how simulation, repetition, feedback, and realistic practice may support competency development. A quantitative descriptive survey design was employed using a survey questionnaire administered to 110 randomly selected senior high school and college Aviation Technology Major in Flying students. Data were analyzed using frequency, percentage, and weighted mean. Results showed consistently high perceived effectiveness of pre-flight simulation training across the assessed competencies. Flight readiness and willingness to recommend simulation training obtained the highest weighted means of 4.88, followed by its perceived contribution to aviation safety at 4.79 and instructor guidance at 4.76. Availability of sufficient simulator practice time received the lowest, although still high, weighted mean of 4.42, indicating a potential area for institutional attention. Overall, respondents perceived simulation training as beneficial for strengthening knowledge, technical competencies, emergency preparedness, confidence, safety awareness, and readiness for real-world flight conditions. The study recommends further integration of structured simulation activities, instructor guidance, feedback, updated training technologies, and continuing simulation exposure in aviation education, while future research should examine long-term skill retention and objectively measured flight performance. The study primarily supports SDG 4—Quality Education and SDG 9—Industry, Innovation and Infrastructure, with a secondary connection to SDG 8—Decent Work and Economic Growth. Its sustainability impact lies in strengthening educational, technological, institutional, safety, and workforce development practices within aviation training.

Keywords: Aviation Safety; Flight Readiness; Flight Simulation; Pre-Flight Simulation Training; Simulation-Based Learning; Situational Awareness; Technical Competence

1. Introduction

Pilot training requires the systematic development of technical knowledge, procedural competence, decision-making, situational awareness, and the capacity to respond appropriately to routine and abnormal flight conditions. Because aviation operates within a safety-critical environment, pilot preparation cannot depend solely on theoretical instruction. Learners must repeatedly practice the application of knowledge under conditions that approximate the operational demands of actual flight. The original study identifies pre-flight simulation as a mechanism through which aviation students may strengthen knowledge of aircraft systems and flight procedures, practice maneuvers and emergency responses, and improve their preparedness before actual flight operations.

Contemporary flight simulation provides a controlled training environment in which flight conditions, operational procedures, workload, and abnormal scenarios can be reproduced without exposing learners, aircraft, or the public to the risks associated with actual-flight experimentation. Kozuba and Sładkowski (2019) emphasized the role of simulators in both basic and recurrent aviation training, particularly in developing the technical and specialist competencies required of aviation personnel. Simulation is therefore most appropriately understood not as a replacement for actual flight experience but as an instructional bridge between theoretical learning and operational application. More recent evidence likewise suggests that simulator effectiveness depends on the competency being developed, the fidelity of the simulator, the design of the scenario, and the extent to which learning transfers to operational conditions (Paul et al., 2025). The relevance of this training approach has increased as aviation education incorporates full-flight simulators, flight training devices, desktop simulation, virtual reality (VR), augmented reality (AR), mixed reality (MR), and other digitally mediated training environments. Fussell and Truong (2020) observed that immersive technologies are increasingly entering aviation education, but their instructional usefulness is influenced by students' acceptance and willingness to use such systems. Consequently, evaluating simulation training requires attention not merely to the presence of technology but also to training design, realism, feedback, task relevance, learner engagement, and alignment between simulation activities and intended pilot competencies. Within this context, the present study examines the perceived effectiveness of pre-flight simulation training among aviation students, particularly in terms of knowledge and skills development, emergency preparedness, decision-making, reaction time, situational awareness, maneuver performance, reduction of errors, and overall flight readiness. These dimensions correspond directly to the areas identified in the study's research questions. The study is significant because it considers simulation not merely as a technological training aid but as part of a broader competency-development process involving educational practice, aviation safety, human performance, technological innovation, and workforce preparation.

Aviation demands high levels of human performance, requiring pilots to integrate aircraft control, procedural knowledge, communication, judgment, monitoring, and situational awareness under changing operational conditions. This makes extensive preparation essential before pilots assume greater flight responsibilities. As stated in a global study by Jaroslaw Kozuba et al. (*Simulators as an Essential Tool for Shaping the Competence of the Aviation Personnel*), simulators help develop and maintain the technical and specialist competencies required in aviation. Kozuba and Sładkowski (2019) likewise emphasized their value in both initial and recurrent training, particularly for situations that are difficult, costly, or unsafe to reproduce in actual aircraft. Simulation is especially useful for practicing emergencies, system abnormalities, complex procedures, and rapidly changing scenarios. Landman et al. (2018) found that pilots trained under unpredictable and variable simulator conditions performed better when later exposed to unexpected situations, showing the importance of adaptive rather than purely repetitive training. Simulation also supports repeated practice, structured feedback, and progressive difficulty. Hajian (2019) noted that transfer of learning is strengthened through coaching, assessment, interaction, scaffolding, and reflection. However, simulation does not provide equal benefits for all skills. Paul et al. (2025) found that VR and desktop simulators were useful for procedural training but had limitations for aircraft-handling skills. Thus, simulation effectiveness depends on the competency being developed, the training objective, instructional design, and simulator fidelity.

The literature highlights several themes on the effectiveness of flight simulation. First, simulation supports procedural and technical competence by allowing students to apply knowledge of aircraft systems, cockpit procedures, navigation, communication, and operational sequences in a contextualized setting. Kozuba and Sładkowski (2019) emphasized its role in developing specialist aviation competence, while Paul et al. (2025) showed that even lower-fidelity simulators can be useful for selected procedural tasks. Second, simulation strengthens emergency preparedness and decision-making by exposing learners to abnormal conditions that may be unsafe to reproduce in actual flight. Landman et al. (2018) found that variable and unpredictable scenarios improved pilots' ability to respond to unexpected situations, supporting the use of adaptive rather than purely repetitive training. A third theme concerns situational awareness and cognitive workload. Koglbauer and Braunstingl (2018) reported improved performance following naturalistic simulation training, while Lu et al. (2020) showed that cognitive load affects visual search and attention during simulated flight. A fourth theme is technology acceptance and learning experience. Based on an international study conducted by Stephanie G. Fussell et al. (*Preliminary Results of a Study Investigating Aviation Student's Intentions to Use Virtual Reality for Flight Training*), emerging technologies such as VR, AR, and MR can enhance training when realism, usability, relevance, feedback, and flexibility are considered. Fussell and Truong (2020) further noted that students' perceptions influence their willingness to use these technologies. Finally, Hajian (2019) emphasized that feedback, coaching, assessment, scaffolding, and reflection strengthen transfer of learning. Overall, effective simulation depends not only on technology but also on appropriate fidelity, realistic scenarios, sufficient practice, instructor guidance, meaningful feedback, cognitive-load management, and transfer to actual performance.

At the global level, simulator-supported instruction is embedded within contemporary approaches to aviation competency development. The International Civil Aviation Organization's *Procedures for Air Navigation Services—Training (PANS-TRG), Doc 9868*, Third Edition, includes provisions on competency-based training and assessment, evidence-based recurrent training using flight simulation training devices, and upset prevention and recovery training (International Civil Aviation Organization [ICAO], 2020). Thus, simulation is not merely an optional educational technology; when appropriately designed and regulated, it forms part of the broader international architecture for aviation training and competency assurance. In the Philippine context, the Civil Aviation Authority of the Philippines (CAAP) exercises regulatory oversight of Approved Training Organizations and specifically evaluates training programs, instructors, facilities, aircraft, flight simulation training devices, equipment, quality systems, safety-management arrangements, and student-training activities. This regulatory context is becoming even more relevant because CAAP announced in 2026 that it would formally implement Competency-Based Training and Assessment, emphasizing robust course design, instructor qualification, and data collection for continuous improvement in training effectiveness (Civil Aviation Authority of the Philippines [CAAP], 2026). Locally, the present research is situated at Indiana Aerospace University in Lapu-Lapu City and focuses on aviation students preparing for progressively more demanding flight-related competencies. This institutional setting provides an appropriate environment for examining how learners themselves perceive the contribution of pre-flight simulation to their readiness, knowledge, emergency response, and flight-related skills. Such evidence can complement regulatory and experimental perspectives by providing institution-specific information that may support curriculum review, simulator-session design, instructor practices, and decisions concerning the allocation of simulation opportunities. The study also refers to an Airlink Flight School article as evidence for the instructional usefulness of simulator practice. For accuracy, AirLink should not be described as a Philippine “national” source: the cited flight school operates in the United States. Its 2024 training description nevertheless provides an industry-practice example of combining ground instruction, high-fidelity simulator practice, and actual flight training (Kurra, 2024). This correction removes a geographic contradiction while retaining the relevant instructional idea.

The study is anchored on an integrated conceptual basis that explains how simulation supports learning beyond mere exposure to technology. Experiential learning emphasizes the importance of realistic practice, feedback, reflection, and repeated application, allowing students to transform theoretical knowledge into practical and operational competence. Through simulation, student pilots can experience flight-related situations in a controlled environment, evaluate their actions, recognize errors, and apply adjustments during succeeding training sessions. This process makes learning more active and performance-oriented rather than purely dependent on classroom instruction. Transfer of Learning is also central to the study because knowledge and skills developed in a simulator are valuable only when they can be applied effectively under changing and real-world flight conditions. Hajian (2019) noted that transfer is strengthened through contextualized practice, coaching, scaffolding, assessment, and reflection. Similarly, Landman et al. (2018) demonstrated that variable and unpredictable simulator scenarios can improve performance when pilots later encounter unexpected situations. These findings suggest that simulation should not focus only on rehearsing fixed procedures but should also prepare learners to adapt their knowledge and responses to unfamiliar operational demands. Cognitive Load Theory further explains how simulation can support learning by managing task complexity and information-processing demands. Sweller et al. (2019) emphasized that instructional design should consider the limitations of working memory while helping learners develop organized knowledge structures. This is particularly relevant in aviation, where pilots must simultaneously process information from instruments, communications, environmental conditions, and operational procedures. Lu et al. (2020) further showed that cognitive load influences attention allocation and performance during simulated flight. Accordingly, well-structured simulation can introduce tasks progressively, allowing student pilots to build procedural fluency before engaging in more complex scenarios. Based on these perspectives, the study views structured pre-flight simulation—through realistic scenarios, repetition, practice, feedback, instructor guidance, and controlled exposure—as contributing to three interconnected competency domains: knowledge and procedural understanding; operational and emergency-response skills, including decision-making, reaction time, situational awareness, and maneuver proficiency; and safety-related preparedness, including error reduction and readiness for actual flight. Together, these domains provide a coherent basis for examining how student pilots perceive the educational value and effectiveness of pre-flight simulation training.

Although the study generally supports simulation-based aviation training, important gaps remain. Simulation effectiveness is competency-specific rather than universal, as simulator fidelity can affect procedural learning, situational awareness, responses to unexpected events, and aircraft-handling skills (Koglbauer & Braunstingl, 2018; Landman et al., 2018; Paul et al., 2025). Transfer to actual flight is also not automatic. Hajian (2019) emphasized that transfer depends on learning conditions, while Landman et al. (2018) showed that scenario variability can improve performance in unexpected situations. Another gap is the limited institution-specific evidence on how students at Indiana Aerospace University perceive pre-flight simulation across knowledge, skills, emergency preparedness, situational awareness, maneuvers, error reduction, and flight readiness. The present study addresses this gap by assessing the perceived effectiveness and educational contribution of simulation training within these domains. Using a descriptive survey approach, it focuses on student perceptions rather than experimental causality and may identify strengths and areas for improvement in practice time, scenario design, instructor feedback, and integration with actual-flight preparation. Future experimental or longitudinal studies may determine whether these perceptions correspond with objectively measured flight performance.

The study most directly contributes to SDG 4 – Quality Education, particularly Targets 4.3 and 4.4 concerning access to quality technical and tertiary education and the development of relevant technical and vocational skills. Aviation education is a highly specialized form of professional and technical preparation, and evidence-based use of flight simulation can contribute to more relevant, competency-oriented learning experiences. The United Nations also recognizes the increasing need for education systems to integrate technology while ensuring that learners acquire skills suited to an evolving labor market (United Nations, 2026). The study also supports SDG 9 – Industry, Innovation and Infrastructure, particularly the emphasis on technological capability, research, and innovation. Flight simulators, VR systems, digital training environments, and related instructional technologies represent aviation-specific applications of technological innovation. However, the study's contribution to SDG 9 lies not simply in promoting more technology; rather, it contributes by assessing whether technology is meaningfully associated with the development of competencies needed by future aviation professionals. This emphasis is consistent with SDG 9's focus on strengthening technological capabilities and research-based innovation (United Nations, 2026). A secondary connection exists with SDG 8 – Decent Work and Economic Growth, particularly Target 8.2, which emphasizes productivity through technological upgrading and innovation, and the broader objective of preparing people for productive employment. Aviation requires a highly skilled technical workforce; thus, strengthening competency-oriented pilot education can contribute to the development of human capital needed within the sector. The present research does not claim to create employment directly, but it can inform training practices that better prepare aviation students for professional competency requirements.

The multidisciplinary sustainability contribution of this research is principally educational, technological, institutional, safety-oriented, and socio-economic. From an educational sustainability perspective, simulation provides a repeatable environment in which learners can develop and maintain competencies through practice, feedback, reflection, and progressively demanding scenarios. Findings from the study may assist aviation educators in determining which areas of simulation students perceive as most useful and which dimensions require instructional improvement. From the perspective of technological and digital sustainability, the research encourages evidence-based adoption of aviation-training technology. Emerging systems should not be integrated simply because they are technologically advanced. The findings of Paul et al. (2025), for instance, demonstrate that the suitability of simulator fidelity differs across procedural and aircraft-handling tasks. Sustainable technological integration therefore requires institutions to match simulator capabilities with learning outcomes, instructor expertise, and the competencies students actually need. The research also contributes to institutional sustainability because competency data can inform curriculum development, simulator scheduling, instructor-development initiatives, scenario design, assessment practices, and continuous improvement. Such an approach is consistent with the broader transition toward competency-based aviation training promoted by ICAO and currently being strengthened within the Philippine regulatory environment by CAAP. Finally, the study has implications for socio-economic and workforce sustainability by contributing knowledge relevant to the preparation of competent future aviation professionals. Stronger alignment between educational practices, technology, industry competencies, and regulatory expectations can support a more resilient aviation-training system. However, the present research does not directly measure environmental sustainability, fuel consumption, emissions reduction, or ecological outcomes; consequently, such environmental benefits should not be claimed without additional empirical evidence. This limitation keeps the sustainability argument proportionate to what the study can genuinely support.

2. Material and methods

2.1 Research Design

The study used a descriptive survey research design to determine the perceived effectiveness and relevance of pre-flight simulation training among Aviation Technology Major in Flying students at Indiana Aerospace University. The design was selected because it enabled the researcher to systematically describe the respondents' perceptions and experiences regarding simulation training. Specifically, the study examined how student pilots perceived simulation training in relation to knowledge, skill development, safety, emergency procedures, decision-making, reaction time, situational awareness, maneuver proficiency, pilot error reduction, and overall flight preparedness. The descriptive approach was appropriate because the investigation focused on describing the existing perceptions of a defined group of student pilots rather than manipulating training conditions or establishing experimental causality. Data collection, organization, analysis, and interpretation were therefore directed toward providing a quantitative description of the respondents' assessment of pre-flight simulation training.

2.2 Locale of the Study

The study was conducted at Indiana Aerospace University (IAU), located at IAU Town Center, Kagudoy Road, Basak, Lapu-Lapu City, Philippines. The institution was established in 1992 and was formerly known as the

Indiana School of Aeronautics before becoming Indiana Aerospace University. The university serves as the educational setting of the respondents enrolled in aviation-related programs and was therefore the locale from which the data for the study were obtained.

2.3 Respondents of the Study

The respondents consisted of 110 student pilots enrolled in Aviation Technology Major in Flying programs at Indiana Aerospace University. The participants represented both senior high school and college levels. Of the total respondents, 20 were Grade 11 students, 24 were Grade 12 students, 40 were first-year college students, 16 were second-year college students, five were third-year college students, and five were fourth-year college students. In terms of sex distribution, the respondent group consisted of 85 males and 25 females. Across the different year levels, the study included students at varying stages of aviation education, thereby allowing the investigation to obtain responses from learners with different levels of academic progression and exposure to aviation training.

2.4 Sample and Sampling Procedure

The study utilized a sample of 110 student pilots from the senior high school and college Aviation Technology Major in Flying programs of Indiana Aerospace University. According to the original methodology, respondents were randomly selected from students currently enrolled in the program. The sample included respondents from Grade 11 through the fourth year of college to provide representation across the different academic levels. The distribution consisted of 20 Grade 11 students, 24 Grade 12 students, 40 first-year students, 16 second-year students, five third-year students, and five fourth-year students. No additional procedure for determining the sample size or implementing the random selection process was specified in the study.

2.5 Research Instrument

The primary research instrument was a survey questionnaire developed to gather quantitative data relevant to the research questions. The questionnaire obtained information concerning student pilots' perceptions of pre-flight simulation training, including its contribution to knowledge, skills, safety, emergency preparedness, decision-making, reaction time, situational awareness, maneuver performance, and overall flight preparedness. The questionnaire served as the primary means of collecting information that was subsequently organized, analyzed, interpreted, and used to address the research problem. The manuscript further indicates that the survey questions were written using simple language to make them understandable to the respondents and facilitate appropriate responses.

2.6 Data Gathering Procedure

Data were gathered through the administration of the survey questionnaire to the selected student pilots of Indiana Aerospace University. The questionnaire was administered to the 110 respondents representing the senior high school and college levels of the Aviation Technology Major in Flying program. During survey administration, the researcher ensured that the questions were expressed in simple and understandable language so that respondents could clearly interpret and answer the items. The responses obtained from the survey constituted the primary data used to address the research questions and assess the respondents' perceptions regarding the effectiveness of pre-flight simulation training.

2.7 Data Analysis Techniques

The collected data were analyzed using frequency, percentage, and weighted mean. Frequency was used to determine the number of respondents corresponding to particular response categories and demographic characteristics. Percentage was computed by dividing the frequency by the total number of respondents and multiplying the result by 100. The weighted mean was used to summarize the respondents' ratings of the survey statements concerning pre-flight simulation training. It was computed as $WM = \Sigma fx/N$, where f represented the frequency of responses, x represented the assigned rating or weight, and N represented the total number of respondents. These descriptive statistical techniques were used to organize and summarize the survey responses and determine the overall pattern of respondents' assessments.

3. Results and Discussion

3.1 Profile of the Respondents

The study involved 110 student pilots between 15 and 23 years of age. The largest age group was 17 years old, comprising 22.73% of the respondents, followed by those aged 18 years at 20.00%, 16 years at 16.36%, 19 years at 15.45%, and 20 years at 14.55%. Smaller proportions were recorded among respondents aged 21 to 23 years. In terms of sex, 85 respondents or 77.27% were male, while 25 or 22.73% were female. Regarding academic level, 44 or 40.00% were senior high school Aviation Technology students, 40 or 36.36% were first-year college students, 16 or 14.55% were second-year students, and five each were third- and fourth-year students. The distribution indicates that the findings largely represent younger and earlier-stage aviation learners, particularly senior high school and first-year college students. This characteristic is relevant when interpreting the results because students at early stages of flight education are still developing procedural familiarity, mental models, cockpit awareness, and confidence. Recent research has shown that simulation can be introduced effectively during ab initio training to provide early opportunities for practicing procedures and developing situational awareness before students accumulate extensive actual-flight experience (Koglbauer & Braunstingl, 2018).

3.2 Perceived Contribution of Simulation to Knowledge and Flight Readiness

3.2.1 Readiness for Flight

The findings showed very strong perceptions of the contribution of simulation to flight readiness. Among the respondents, 82.73% strongly agreed and 16.36% agreed that pre-flight simulation training helped them remain prepared when flying, while only 0.91% selected a neutral response. The item obtained a weighted mean of 4.88, indicating a very high level of agreement. Anchored by David Kolb's Experiential Learning Theory, the result reflects the value of learning through direct and repeated experience. Simulated flight situations allow student pilots to practice before entering actual operational environments, observe the consequences of their decisions, identify deficiencies, and adjust succeeding performance. Recent evidence provides additional support for this interpretation. Paul et al. (2025) found that simulator environments can provide meaningful benefits for ab initio pilot training, particularly for procedural tasks, although the effectiveness varies according to the competency and simulator fidelity. Thus, the present finding suggests strong perceived preparedness rather than establishing that simulation independently guarantees equivalent actual-flight performance.

3.2.2 Understanding of Aircraft Systems

A similarly strong response was recorded for understanding aircraft systems. Approximately 85.45% strongly agreed and 11.82% agreed that pre-flight simulation enhanced their understanding of aircraft systems, while 2.73% were neutral. The resulting weighted mean of 4.82 reflected very high agreement among the respondents. Anchored by John Sweller's Cognitive Load Theory, the finding suggests that simulation may assist learners in becoming familiar with complex information under controlled conditions before they encounter the simultaneous demands of actual flight. In simulator environments, tasks can be repeated and introduced progressively, potentially allowing learners to organize procedural and systems knowledge more efficiently. Paul et al. (2025) similarly identified particular potential for VR and desktop simulators in procedural training, although they cautioned that such systems have limitations for some aircraft-handling tasks.

3.2.3 Knowledge of Flight Procedures

Regarding knowledge of flight procedures, 82.73% strongly agreed and 16.36% agreed that pre-flight simulation improved their knowledge, whereas only 0.91% selected a neutral response. No respondent disagreed. The weighted mean was 4.82, demonstrating very high perceived effectiveness. Anchored by B.F. Skinner's Behavioral Learning Theory, pre-flight simulation provides an environment where correct responses regarding flight procedures can be reinforced, thereby improving student pilots' retention of this knowledge. Repeated procedural execution coupled with corrective information can help learners recognize errors and strengthen appropriate responses. Contemporary experimental evidence is consistent with this interpretation: Paul et al. (2025) specifically found potential advantages of VR and desktop simulators for developing procedural competencies among ab initio pilots. The finding therefore supports simulation as a complement to, rather than a substitute for, actual aircraft instruction.

3.3 Perceived Development of Emergency and Cognitive Competencies

3.3.1 Decision-Making During Flight

For decision-making, 74.55% of the respondents strongly agreed and 20.91% agreed that simulation training improved their decision-making during flight. Another 3.64% were neutral and 0.91% disagreed. The weighted mean of 4.70 indicated a very high assessment of simulation's contribution to this competency. This belief is supported by Kolb's Experiential Learning Theory, while John Sweller's Cognitive Load Theory also supports the role of structured exposure in helping learners manage demanding situations. Additionally, the findings relate to B.F. Skinner's Behavioral Learning Theory through the corrective feedback available during repeated practice. Decision-making in aviation is particularly complex because pilots must manage competing goals, uncertainty, time constraints, and incomplete information. Research on simulator-based dynamic decision-making has emphasized that simulation can expose pilots to circumstances in which standard procedures alone are insufficient, helping them examine decision processes and adaptive problem-solving strategies (Rosa et al., 2021).

3.3.2 Reaction Time During Emergency Procedures

The respondents also perceived simulation as beneficial to their reaction during emergencies. A total of 71.82% strongly agreed and 18.18% agreed that pre-flight simulation improved their reaction time during emergency procedures. In contrast, 8.18% were neutral and 1.82% disagreed. The item recorded a weighted mean of 4.61, indicating a very high assessment. This view is backed by Kolb's Experiential Learning Theory, which emphasizes learning through direct experience, while B.F. Skinner's Behavioral Learning Theory is also relevant because repeated training and immediate corrective responses can reinforce appropriate actions. Simulation is particularly useful for emergency education because rare or hazardous circumstances can be practiced without intentionally creating the corresponding danger during actual flight. Research on unexpected-event training further indicates that exposing pilots to variable and unpredictable scenarios can improve their preparation for situations that differ from previously rehearsed events (Landman et al., 2018). This suggests that emergency simulation should progressively include scenario variability rather than relying exclusively on repeated, predictable drills.

3.3.3 Situational Awareness

The findings further revealed strong perceived improvement in situational awareness. Approximately 75.45% strongly agreed and 16.36% agreed that simulation training helped them develop better cockpit situational awareness, while 7.27% were neutral and 0.92% disagreed. The weighted mean of 4.66 reflected very high agreement. This aligns with Kolb's Experiential Learning Theory, which emphasizes learning through hands-on experiences. John Sweller's Cognitive Load Theory also supports these findings because familiarization with cockpit tasks and simulated scenarios may help learners allocate attention more efficiently as competence develops. Importantly, this relationship has also received empirical support in aviation research. Koglbauer and Braunstingl (2018) found that ab initio pilots who received naturalistic simulator training demonstrated superior situational awareness and procedural performance and experienced lower workload in several traffic-monitoring tasks than a control group. This strengthens the interpretation that appropriately designed simulation may provide a useful environment for developing situational awareness early in pilot training.

3.4 Skill Development, Practice, and Performance Feedback

3.4.1 Multitasking During Flight Operations

Regarding multitasking, 75.45% strongly agreed and 17.27% agreed that simulation training improved their ability to multitask during flight operations, while 7.27% remained neutral. No respondents disagreed with the statement. The item obtained a weighted mean of 4.68, demonstrating very high perceived effectiveness. Anchored by Jean Lave et al.'s Situated Learning Theory, the finding reflects the value of practicing competencies within contexts similar to those in which they will eventually be performed. Flight simulation can require learners to monitor instruments, navigate, communicate, manipulate controls, and maintain awareness simultaneously. Koglbauer and Braunstingl (2018) demonstrated that naturalistic simulator environments can improve procedural performance while reducing workload associated with monitoring and traffic-awareness activities. Thus, realistic simulation may help students progressively coordinate multiple demands before performing them under the consequences and workload of actual flight.

3.4.2 Identification of Areas for Improvement

When asked whether simulators effectively identified areas requiring improvement, 74.55% strongly agreed and 20.91% agreed. Only 3.64% were neutral and 0.91% disagreed. The weighted mean was 4.70, indicating that respondents strongly perceived simulation as useful for identifying deficiencies in their performance. Anchored by Anders Ericsson's Deliberate Practice Theory, the finding emphasizes the importance of focused practice directed toward particular areas of weakness. Simulation enables procedures and maneuvers to be repeated while learners receive information about their performance. Rather than repetition alone, effective practice requires clear performance goals and opportunities to correct deficiencies. This is particularly relevant to contemporary simulation because advanced training environments can record and reproduce scenarios, allowing instructors and learners to identify specific aspects of performance that require remediation.

3.4.3 Availability of Simulator Practice Time

The item concerning sufficient simulator time produced the lowest weighted mean among the reported indicators, although it remained high at 4.42. Sixty percent strongly agreed and 26.36% agreed that sufficient simulator time was available before actual flight. However, 10.91% were neutral, 0.91% disagreed, and 1.82% strongly disagreed. This belief is supported by Anders Ericsson's Deliberate Practice Theory, which suggests that having enough time in the simulator allows student pilots to practice various flight maneuvers and emergency procedures in a structured manner. The comparatively lower rating of this item is noteworthy because it suggests that availability of practice time may be a more variable aspect of the training experience than students' perceptions of simulation's educational value. Current research also indicates that simulator effectiveness depends not simply on having access to simulation technology but on how the technology is integrated into the training sequence. Paul et al. (2025), for example, found differences in training usefulness depending on simulator fidelity and the specific task being practiced.

3.4.4 Simulator Feedback

Regarding feedback, 69.09% strongly agreed and 26.36% agreed that feedback received during simulator sessions improved their flying skills, while only 4.55% were neutral. The weighted mean was 4.64, demonstrating very high perceived value of simulator-based feedback. Supported by B.F. Skinner’s Behavioral Learning Theory, these findings suggest that feedback received from simulator sessions contributes to the flying skills of the student pilots, allowing them to nurture their skills and correct their mistakes. The instructional value of simulation therefore does not arise solely from technological realism. Its usefulness also depends on whether learners can recognize incorrect actions, understand why errors occurred, and modify subsequent performance. This reinforces the importance of integrating structured feedback and debriefing into simulator sessions rather than treating the simulator itself as an independent instructional intervention.

3.4.5 Instructor Guidance

Instructor involvement received one of the strongest ratings. Approximately 79.09% strongly agreed and 19.09% agreed that instructor guidance during simulator sessions contributed to overall performance, while 1.82% were neutral. The corresponding weighted mean was 4.76. Supported by B.F. Skinner's Behavioral Learning Theory, these findings suggest that instructor's guidance during training sessions contributes to the overall performance of the student pilot, allowing them to shape their knowledge and enhance their skills. This result underscores that simulation-based education remains an instructor-mediated process. Technology creates opportunities for repeated and controlled practice, but instructors contextualize scenarios, identify mistakes, explain performance standards, and guide reflection. Consequently, the quality of simulator instruction should be considered alongside equipment fidelity when evaluating aviation training effectiveness.

3.5 Safety and Transfer to Real-World Flight

3.5.1 Contribution to Aviation Safety

The respondents strongly associated pre-flight simulation with aviation safety. A total of 83.64% strongly agreed and 11.82% agreed that simulation contributes to overall aviation safety, while 4.55% were neutral. No respondent disagreed. The weighted mean was 4.79, making safety one of the most strongly rated dimensions. This belief is anchored by Frederic Bartlett's Schema theory, as repeated practice may allow student pilots to develop more organized mental frameworks for recognizing and responding to flight situations. Additionally, John Sweller's Cognitive load Theory suggests that knowledge becomes increasingly organized as expertise develops. The safety value of simulation is especially relevant because high-risk or unusual conditions can be presented in a controlled environment. White et al. (2021), in their review of flight-simulator fidelity for loss-of-control training, emphasized that appropriate simulator characteristics are important for developing training intended to address safety-critical flight conditions. Thus, simulation's safety contribution depends on the accuracy and suitability of the training environment for the targeted competencies.

3.5.2 Preparation for Real-World Flying Conditions

The respondents likewise reported strong perceived transfer to real-world preparation. Approximately 69.09% strongly agreed and 26.36% agreed that simulator training prepared them for real-world flying conditions, while 4.55% were neutral. The weighted mean of 4.64 indicated very high perceived effectiveness. Anchored by Jean Lave et al.'s Situated Learning Theory, simulator training can place students in contextualized environments that resemble the conditions in which their knowledge will ultimately be applied. However, realism alone does not guarantee complete transfer. Paul et al. (2025) demonstrated that simulator fidelity has different implications for procedural and aircraft-handling tasks, supporting the view that simulator training is most effective when its capabilities match specific learning outcomes. Recent systematic evidence on extended-reality pilot training similarly indicates an overall positive effect on pilot performance, while emphasizing that effectiveness varies considerably according to implementation, technology, and the targeted skill (2025 systematic review).

3.5.3 Perceived Reduction of Pilot Errors

Regarding error reduction, 70.91% strongly agreed and 20.00% agreed that simulation training reduced the likelihood of pilot errors, whereas 9.09% selected a neutral response. No respondents disagreed. The weighted mean was 4.62, indicating a very high perception that simulation can contribute to error prevention. Anchored by Frederic Bartlett's Schema Theory, repeated simulation may help learners build and refine mental frameworks for flight procedures, enabling information to be recognized and retrieved more systematically during subsequent tasks. The finding should nevertheless be interpreted as a perception of error reduction, rather than direct evidence that the respondents committed fewer errors during actual flight. This distinction is important because objective verification would require performance records, observational data, or an experimental comparison. Nonetheless, evidence from simulator-training research suggests that structured simulation can improve targeted procedural and situational-awareness competencies associated with safer flight performance (Koglbauer & Braunstingl, 2018; Paul et al., 2025).

3.6 Overall Acceptance of Pre-Flight Simulation Training

The strongest endorsement was observed in students' willingness to recommend pre-flight simulation training. Ninety percent strongly agreed and 8.18% agreed that they would recommend the training to other student pilots, while only 1.82% remained neutral. No respondent expressed disagreement. The weighted mean was 4.88, demonstrating an exceptionally high level of perceived acceptance and usefulness. Anchored by Jean Lave et al.'s Situated Learning Theory, this strong agreement reflects the perceived relevance of learning within an environment that approximates actual professional activity. Contemporary research similarly demonstrates substantial interest in integrating immersive simulation into ab initio aviation education. Paul et al. (2025) found meaningful potential for simulator technologies in procedural training, while recent evidence on VR-integrated flight instruction indicates that such technologies can form part of an effective blended training model when their limitations are recognized. A 2025 systematic review and meta-analysis of extended-reality applications in pilot training likewise reported an overall positive and statistically significant effect on pilot performance, although the authors emphasized variation across technologies and training applications (Somerville et al., 2025). Overall, the results consistently indicate that the respondents perceived pre-flight simulation training as highly beneficial across knowledge, procedural preparation, decision-making, emergency response, situational awareness, multitasking, feedback, instructor guidance, safety, and readiness for actual flying. The highest weighted means of 4.88 were recorded for flight readiness and willingness to recommend simulation training, while sufficient simulator practice time received the comparatively lowest rating of 4.42. These results suggest broad student acceptance of simulation while also indicating that the amount of available practice may merit greater institutional attention. Because the study used self-reported survey data rather than objective performance measurements, the findings are most appropriately interpreted as evidence of strong perceived effectiveness, not as causal proof that simulation alone produces equivalent improvements in actual-flight performance.

4. Conclusion & Recommendations

The findings indicate that the student pilots perceived pre-flight simulation training as highly beneficial in developing knowledge, skills, preparedness, and safety-related competencies. Simulation training supported their understanding of aircraft systems and flight procedures and provided a controlled environment for practicing emergency situations, decision-making, reaction time, situational awareness, and flight maneuvers. The respondents also recognized the importance of instructor guidance and feedback in identifying weaknesses, correcting errors, and improving performance. Overall, pre-flight simulation training was perceived to strengthen student pilots' confidence, technical competence, preparedness for real-world flying conditions, and awareness of aviation safety while helping reduce the likelihood of pilot errors.

Pre-flight simulation training should be further integrated into pilot education by encouraging student pilots to actively participate in simulation sessions, use instructor feedback to identify areas for improvement, and monitor their progress before actual flight. Certified pilots should also incorporate simulation into continuing professional development and provide mentorship to student pilots. Flight instructors should design structured simulation activities that address specific competencies and relevant flight scenarios while providing appropriate guidance and feedback. Simulator manufacturers and developers should maintain high-fidelity systems and regularly update training modules according to current industry practices, technologies, and regulations. Future researchers are encouraged to examine the long-term effects of simulation training on pilot performance and skill retention and compare different simulation-training approaches across pilot-training contexts.

The study is limited to data obtained through survey responses from 110 student pilots enrolled in the STEM-Aviation Technology Major in Flying and Bachelor of Science in Aviation Technology Major in Flying programs at Indiana Aerospace University; consequently, the findings primarily represent the respondents' perceptions within this particular institutional setting. Since the study relied on questionnaire-based assessments, it did not directly measure actual flight performance or objectively determine whether the perceived improvements translated into corresponding changes during real flight operations. Furthermore, long-term pilot performance and skill retention were outside the scope of the investigation, as these were specifically identified in the manuscript as areas for future research.

5. Compliance with ethical standards

The author affirms that no conflict of interest exists in relation to this study. The research involving student pilots was conducted in accordance with accepted ethical principles for human-participant research. Participation in the survey was voluntary, and respondents were informed of the purpose of the study and their right to decline or withdraw from participation without penalty. Informed consent was obtained prior to data collection, and the confidentiality and anonymity of the respondents were protected throughout the research process. Survey responses were handled securely and reported only in aggregated form to prevent the identification of individual participants. Since the study involved a non-invasive questionnaire assessing student pilots' perceptions of pre-flight simulation training, no physical intervention or experimental exposure to flight-related risks was involved. Appropriate institutional permission was obtained before the administration of the research instrument to the participating Aviation Technology students of Indiana Aerospace University.

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