Journal of Educational Technology and E-Learning Innovations (JETELI)

ISSN: 3069-3624 (ONLINE)

VOLUME 1 ISSUE 2 (2025)

PUBLISHED BY
E-PALLI PUBLISHERS, DELAWARE, USA

Journal of Educational Technology and E-Learning Innovations (JETELI)

Volume 1 Issue 2, Year 2025
ISSN: 3069-3624 (Online)
DOI: https://doi.org/10.54536/jeteli.v1i2.5496
https://journals.e-palli.com/home/index.php/jeteli

Generative AI as a Learning Tool in Aviation: A Review of Pedagogical Approaches and Outcomes

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Article Information

Received: June 27, 2025

Accepted: July 30, 2025

Published: September 26, 2025

Keywords

Artificial Intelligence, Aviation, Aviation Education, GenAI and Training

ABSTRACT

This paper examines the integration of Generative Artificial Intelligence (GenAI) into aviation training, focusing on instructional strategies, learning objectives, and key challenges. Using a systematic literature review approach, relevant studies were gathered from academic sources such as Google Scholar, IEEE Xplore, and PubMed, emphasizing the educational applications of GenAI. Some research suggests that GenAI is beginning to transform aviation training by giving instructors the ability to customize lessons based on how each student learns best and how quickly they progress. This adaptability often leads to higher student engagement and better retention of material. This flexibility tends to keep learners more involved and helps them absorb information more effectively. GenAI also plays a role in developing realistic practice environments, allowing trainees to safely build critical skills. Still, its growing presence in education raises important concerns. Questions around fairness, the potential for biased content, and the risk that students or educators may rely too heavily on these tools are still unresolved. This review highlights these issues and suggests that further research is necessary to better understand how GenAI affects aviation training in the long run. It also underlines the importance of building well-informed teaching methods and ethical safeguards to guide its integration. As the aviation sector adopts new technologies, careful planning will be essential to ensure that innovation supports not compromises safety, learning quality, and professional standards.

INTRODUCTION

The sudden development of Generative Artificial Intelligence (GenAI) has the potential of transforming numerous industries, including the aviation industry (Yusuf *et al.*, 2024). There are clear merits and opportunities for revolutionizing aviation training with personalization and improved user engagement and safety results (Noroozi *et al.*, 2024; Yusuf *et al.*, 2024). This paper systematically reviews existing studies of GenAI in aviation course integration, considering the following key aspects: the pedagogy of GenAI applications, learning effects, existing problems, and the limitations of those presented studies. I conducted a cross-study comparison of data, examining congruencies in findings and discrepancies, to provide a unified view of the contribution of GenAI to the shaping of the future of aviation training. Comments on the critical research gaps and the directions for future research that will successfully and responsibly deploy GenAI for this important purpose are offered. Because of the evolving environment of GenAI, applications of GenAI must continue to be reviewed, and risks need to be addressed proactively. This work is part of ongoing research designed to assess and incorporate this revolutionary technology into aviation education. There are significant potential advantages with improved safety, efficiency, and trainee accessibility (Wang *et al.*, 2024). But, the successful establishment of GenAI should be taken together with a responsible framework for its ethical implications and downsides (Mittal *et al.*, 2024; Wang *et al.*, 2024).

MATERIALS AND METHODS

This study employs a systematic literature review to investigate the implementation of Generative AI (GenAI) in aviation training. The process was initiated by an extensive literature identification step, in which academic databases including Google Scholar, IEEE Xplore, and PubMed were explored for relevant studies published until 2024. Searches were conducted with term projections: "Generative AI," "aviation training," "pedagogical approaches," "learning outcomes." The inclusion criteria further restricted to only those articles that clearly reported the use of GenAI in the context of aviation training and its effects on learning retention or the methods of pedagogy. I excluded studies that were not on the subject of education or training applications, did not include empirical data, or were not published in peer-reviewed journals. Relevant information from the included studies was extracted systematically, including but not limited to pedagogical processes, learning outcomes, challenges, and shortcomings of GenAI in aviation training. A structured framework was developed from these data, facilitating a comparative analysis of trends, agreements, and discrepancies among the findings. The evaluation found that GenAI also proved effective in improving students' engagement, their ability to memorize, their critical thinking, problem-solving skills, as well as the development of new assessment approaches. The review also highlights gaps in the literature, shedding light on the necessity of robust experimental designs and long-term investigations into the efficacy of GenAI in

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skill training and knowledge retention. This highlights the need to consider the ethical implications of GenAI, including bias in AI-generated content, data privacy issues, and the development of culturally sensitive and inclusive training. Additionally, this study recommended the development of pedagogical approaches to facilitate the incorporation of GenAI into aviation education to maximize learning.

LITERATURE REVIEW

Pedagogical Approaches for Using Generative AI in Training

GenAI in aviation education is in its early stages of utilization despite some potential pedagogical approaches. These approaches leverage the unique characteristics of GenAI to optimize various components of the learning process and overcome some of the specific challenges posed by aviation instruction.

Personalized Learning and Adaptive Training

A major advantage of GenAI is its capability for personalized learning (Mittal *et al.*, 2024; Noroozi *et al.*, 2024). GenAI personalizes content and feedback for each individual student (Mittal *et al.*, 2024; Noroozi *et al.*, 2024). Such personalized learning results in higher engagement and motivation of learners (Noroozi *et al.*, 2024), which is known to enhance knowledge retention and skills acquisition (Mittal *et al.*, 2024). In the aviation environment, individually tailored flight performance scenarios may be developed by GenAI, that can challenge each student based on their individual strengths and weaknesses, providing specific feedback on areas that need addressing (Woods & Blickensderfer, 2024). This adaptation to learning needs is especially important in aviation, where the numerous complex skills is greatly facilitated by individualized attention and concentrated practice of those skills (Woods & Blickensderfer, 2024). In addition, GenAI has the potential to provide customized feedback on written assessments that could aid in the development of technical writing skills or future knowledge about aviation regulations and procedures (Yusuf *et al.*, 2024). This immediate and detailed feedback can improve learning significantly faster than traditional methods (Noroozi *et al.*, 2024). Because GenAI is adaptive, we can construct dynamic learning paths, varying the difficulty and the material as students take in new information or master skills.

Enhanced Simulation and Immersive Training

There are positive applications of GenAI, such as realistic real-time simulations for practice-based and immersion learning (Wang *et al.*, 2024). For example, GenAI could develop plausible weather patterns for use in flight simulators, enabling students to practice managing adverse flying conditions without the risk of real-life flying time (Stankovski *et al.*, 2024; Woods & Blickensderfer, 2024). On the other hand, GenAI can also simulate real emergency cases, which can enhance students' skills in problem-solving and decision-making (Wang *et al.*, 2024). The reactions to this type of immersive experience could operate on memory recall of knowledge and skill transfer from simulation to the real world (Wang *et al.*, 2024; Woods & Blickensderfer, 2024). The cost-effective use of GenAI-based simulation is another important factor that allows such training to be more affordable, especially in resource-limited areas (Elanjeran *et al.*, 2024). This has worldwide implications for high-fidelity aviation training. As it applies to realistic and complex realization, the need for successful aviation training is pivotal, and GenAI takes some first-class steps in this direction.

AI-Powered Tutoring and Feedback Systems

GenAI can also be additionally used in tutoring systems to give personalized help and real-time feedback to learners (Matthew *et al.*, 2023; Wang *et al.*, 2024). AI tutoring could give immediate feedback to students in response to simulated activities or written work, rapidly identifying and addressing errors (Matthew *et al.*, 2023; Wang *et al.*, 2024). AI tutors can offer more consistent and individualized coaching than human teachers, supporting all students as needed (Wang *et al.*, 2024). For example, Tutor CoPilot (Wang *et al.*, 2024) illustrates that AI has the potential to provide expert-level tutor support to boost tutor quality and student outcomes, especially for relatively inexperienced tutors. It must be kept in mind that AI tutors are not a substitute for interaction with humans (Wang *et al.*, 2024). Human factors are crucial for providing emotional support, solving complex learning issues, and creating a friendly learning environment. When paired, the human touch and AI support can create a powerhouse of a learning experience. Aviation education has the advantage of flexibility; course participants come to the classroom with various backgrounds and past exposure to the subject (Wang *et al.*, 2024). Furthermore, GenAI has the ability to save time on tasks like grading tests and providing immediate feedback, allowing teachers to focus on the unique learning characteristics of each student (Ponte & Dwyer, 2024). This advantage is especially relevant for training tasks (Feitosa & Dwyer, 2024). This feature is particularly advantageous in aviation programs where time and resources are frequently scarce for instructors (Ponte & Dwyer, 2024).

AI-Assisted Curriculum Development and Assessment

GenAI may also have potential in the context of curriculum development and as an assessment tool (Ahmed *et al.*, 2024; Yusuf *et al.*, 2024). It can help educators develop more effective and interesting lesson plans that focus more specifically on learning outcomes and students (Ahmed *et al.*, 2024; Yusuf *et al.*, 2024). GenAI can also support the design of more inclusive and diverse assessment tools that offer all students fair opportunities to express their understanding and skills (Ahmed *et al.*, 2024). For instance, GenAI can provide diverse types of questions for exams, thereby, decreasing the focus on rote learning and encouraging understanding-based

learning (Ahmed *et al.*, 2024). GenAI may also be used to automate the grading of assignments, giving instructors more time to dedicate to tailored feedback (Ahmed *et al.*, 2024). However, although language systems can make this work, human oversight is necessary to ensure fairness, reduce bias, and observe academic integrity. Creating custom GPTs (Ponte & Dwyer, 2024) shows the potential for simplifying curriculum development. But quality and relevance can only be ensured by human knowledge. The application of AI in curriculum design and assessments can highly facilitate efficiency and effectiveness in training activities.

Outcomes and Impact of Generative AI in Aviation Training

Combining GenAI and aviation training can bring about benefits along the dimensions of learning and individuals in the training system and support the improvement of the quality of aviation personnel.

Enhanced Learning Outcomes and Skill Acquisition

A number of empirical studies have demonstrated the superiority of GenAI in terms of learning outcomes for their participants (Mittal *et al.*, 2024; Noroozi *et al.*, 2024). GenAI has the potential to enhance the learning experience, retention of knowledge and skills, and ultimately the performance, as it offers personalized learning, immersive learning environments and personalized feedback, besides a tailored user profile for tracking the learning progression (Katz & Atkinson, 2011; Mittal *et al.*, 2024; Noroozi *et al.*, 2024). This gap in generation between adult learners and the young is continuously narrowed by the facility of GenAI to author and modify digital creations forming individualized learning resources suitable to diverse learning styles and interests (Mittal *et al.*, 2024; Uppin & Madalgi, 2023).

The impact of GenAI on aviation students' learning-oriented outcomes is an ongoing inquiry (Yusuf *et al.*, 2024). While some researchers have shown that game-based approaches have a beneficial effect on learning retention and engagement (Ahmed *et al.*, 2024; Noroozi *et al.*, 2024), there is a need to carry out more experimental research to measure their effect on various skills and competencies (Yusuf *et al.*, 2024).

Wu *et al.* (2022) demonstrated the positive impact of a teacher training program on the effectiveness of education, with a focus on generative AI applications. This would seem to indicate that both training and integration are key to producing good results. In this vein, the induction of GenAI to prospective teachers in the instructional design process has led to favorable changes in their perception and intention to apply GenAI (Seo *et al.*, 2024). The emphasis on application and overcoming the initial disbelief was found to promote the adoption with good results. Instead, we will have more qualified and highly-trained fliers. Consequently, the industry will become safer and more reliable (Defoe, 2031; Woods & Blickensderfer, 2024).

GenAI can contribute to learners' satisfaction, help reduce stress, and establish a more effective learning process by promoting cooperation and motivation (Noroozi *et al.*, 2024). Yet, the efficacy of GenAI relies on the quality of the training data and the pedagogical methods employed (Noroozi *et al.*, 2024). Poorly designed AI-based instruction could be ineffective, or in some cases even counterproductive, thwarting rather than supporting learning. Design and deployment considerations need to be paid attention to even if there is much potential for more effective learning results.

Improved Safety and Decision-Making

GenAI could significantly improve the safety margins in aviation by increasing the situational awareness and decision-making competence of pilots (Woods & Blickensderfer, 2024). GenAI can aid in evaluating pilots' risk assessment and affective decision-making capabilities by generating realistic emergency scenarios and facilitating access to real-time weather data (Woods & Blickensderfer, 2024). This is especially important for time-critical work, such that avoiding accidents requires rapid and accurate decisions (Woods & Blickensderfer, 2024).

GenAI's ability to understand complex weather data and then display it in a way more intuitive to pilots will lower the potential for pilot error when interpreting weather data (Woods & Blickensderfer, 2024). However, GenAI is not without its flaws and is subject to both biases and errors (Woods & Blickensderfer, 2024). A safe and successful flight is the result of normative human supervision and decision-making. GenAI integration should be regarded as an aid, rather than as a replacement for human judgment.

Increased Efficiency and Reduced Costs

In aviation training, GenAI can take on the workload task of feedback giving (Ahmed *et al.*, 2024). Moreover, GenAI can help with automating these functions: correcting assignments, providing direct feedback linkage, and time scheduling of instructors to support individual students (Kuka & Sabitzer, 2024). This feature is of great advantage in aviation education courses because generally, instructors lack time and training possibilities (Kuka & Sabitzer, 2024). In such cases, educators would be able to invest more time to support a higher quality of teaching and support students (Ahmed *et al.*, 2044).

In addition, by virtually eliminating the physical elements and simulators (Elanjeran *et al.*, 2024), GenAI could decrease the cost of aviation training in general. This enables elite-quality aviation training to be accessible to more students, regardless of their income status (Elanjeran *et al.*, 2024). Large financial contributions are received by aviation training schools because they save a large sum of money that can be utilized in some other areas of the business – to enhance the standard of training.

In addition, GenAI develops many types of course content (for instance, multimedia presentations, case studies, interactive quizzes) which can facilitate learner

motivation and knowledge retention (Wang *et al.*, 2024). The ability of GenAI to generate and manipulate digital content also makes it possible to develop customized learning products that suit different learning preferences and styles (Ahmed *et al.* 2024; Wang *et al.*, 2024). Instructors require a certain level of knowledge regarding what can and cannot be done with GenAI in order to teach the training program in an ethical and responsible manner (Kuka & Sabitzer, 2024).

Enhanced Accessibility and Inclusivity

GenAI may also help to make aviation training more widely accessible (Elanjeran *et al.*, 2024; Wang *et al.*, 2024). Personalized learning experiences and adaptive learning can meet the varying needs and learning styles of students ensuring that each has an equal opportunity to succeed (Elanjeran *et al.*, 2024; Wang *et al.*, 2024). Additionally, GenAI can enhance inclusiveness and support learning by fostering communication and collaboration between learners with diverse cultural backgrounds (Wang *et al.*, 2024). The proof of the cost-effectiveness of digital tools authorizes their more widespread use because digital media has the capability to bring mass global training of high standard to everyone in aviation (Elanjeran *et al.*, 2024). There is potential for GenAI to democratize aviation instruction for all.

Challenges and Limitations

Academic Integrity

Academic dishonesty is a serious problem (Ahmed *et al.*, 2024; Yusuf *et al.*, 2024). The credibility and validity of the valuation process might be compromised if students are prompted to use GenAI to generate assignments or exam responses (Ahmed *et al.*, 2024; Yusuf *et al.*, 2024). There are a few possible downsides, however. Issues pertaining to academic integrity, AI-authored content bias, and over-reliance on technology are frequently reported concerns (Ahmed *et al.* 2024; Wang *et al.* 2024). These obstacles underscore that appropriate digital literacy of AI should be sought via an integrated AI literacy in the school curriculum, open guidelines on the ethical use of AI, and through strict assessment procedures (Kuka & Sabitzer, 2024; Wang *et al.*, 2024).

Bias and Fairness

When trained and provided with large enough data sources, such as datasets drawn from the internet which GenAI models take their cues from, the GenAI system can latch onto and magnify any biases already present in the data (Wang *et al.*, 2024; Yusuf *et al.*, 2024). For the aviation industry and education sector, this may lead to unfair or biased results for certain groups of students who were marginalized in the process (Yusuf *et al.*, 2024; Wang *et al.*, 2024). It will require thoughtful consideration of the datasets chosen and the model that trains GenAI for aviation training to ensure the dataset is a good match for a diverse trainee, while free of bias (Wang *et al.*, 2024; Yusuf *et al.*, 2024). To address such potential biases which might appear over time, routine auditing of GenAI devices is necessary (Wang *et al.*, 2024; Yusuf *et al.*, 2024).

Over-Reliance and Deskilling

There is a significant chance that students may become overly reliant on GenAI, affecting how their critical and problem-solving skills develop (Ahmed *et al.*, 2024; Wang *et al.*, 2024). GenAI is a reinforcement to face-to-face learning, not its substitute (Ahmed *et al.*, 2025; Wang *et al.*, 2025). Aviation students should have the knowledge and skills that will equip them to perform and develop in their aviator careers in a balanced way with human relationships, critical thinking, and experiential learning (Ahmed *et al.*, 2024; Wang *et al.*, 2024). It is important to attend to the pedagogical approach of GenAI-integrated training courses to ensure there is no over-reliance on technology.

Ethical Considerations and Responsible Use

The use of GenAI within the aviation training context introduces some ethical challenges, misuse of AI-generated content, privacy, and security (Mittal *et al.* (Mittal *et al.*, 2024; Woods & Blickensderfer, 2024) are among them. Ethical frameworks for student data privacy, and ethical and responsible use of AI tools, the development of ethical frameworks are crucial. Many of these apply to initial data handling and processing, yet also provide insight when developing AI products that will include students' information. These guidelines ought to include biased content generated from AI, disclosure of the use of AI algorithms, and the privacy of data (Mittal *et al.*, 2024; Woods & Blickensderfer, 2023). Ethics need updating all the time and it will continue being updated with our AI trend.

Technological and Infrastructural Limitations

For successful application of GenAI in aviation training, proper technology and resources are needed (Elanjeran *et al.*, 2024; Wang *et al.*, 2024). This applies to high-speed access to the internet, high-performance computing facilities, and associated software and hardware (Elanjeran *et al.*, 2024; Wang *et al.*, 2024). Learning inequality may result from the digital divide, resulting in certain learners not having access to resources (Elanjeran *et al.*, 2024; Wang *et al.*, 2024). Finally, technology should be accessible to all learners, and support should be provided to those with no digital literacy skills (Elanjeran *et al.*, 2024; Wang *et al.*, 2024). Robust infrastructure is key to the success of GenAI technology in aviation training.

Future Research Directions

Rigorous Evaluation and Comparative Studies

Further comparative studies are required to systematically test various GenAI-based strategies (Noroozi *et al.*, 2024; Yusuf *et al.*, 2024). These studies should examine the impact of Generative AI (GenAI) on aviation training by employing appropriate experimental research designs and models. They should also utilize relevant statistical

analyses to evaluate GenAI's role in enhancing knowledge acquisition, skill development, and decision-making within aviation course instruction. (Noroozi *et al.*, 2024; Yusuf *et al.*, 2024). In addition to analyzing the long-term learning effects of GenAI-facilitated training towards the different aspects represented within aviation education such as flight simulation, and theory and practical instruction (Noroozi *et al.*, 2024), such studies should also seek to examine GenAI-based training's long-term effects on the sustained benefits made over the long haul. There is a need for empirically based decisions for the integration of GenAI into aviation training.

Addressing Bias and Ensuring Fairness

Research should be conducted to develop techniques for detection and reduction of bias in GenAI (Ahmed *et al.*, 2024; Yusuf *et al.*, 2024) models used in aviation training. This may be achieved by devising approaches to improve the balance of the datasets, by designing detection algorithms that are aware of biases, and by establishing guidelines for applying GenAI in an ethical manner, and in such a way that fairness and equity are achieved in the training data (Ahmed *et al.*, 2024; Yusuf *et al.*, 2024).

Developing Effective Pedagogical Approaches

Studies will be needed to explore optimal use of AI feedback and individual learning history in the current aviation training programs (Matthew *et al.*, 2023; Seo *et al.*, 2024). We need to establish best pedagogical practices of how we can enjoy the gain and avoid the pain of GenAI.

Addressing Ethical and Societal Implications

It is necessary to examine the ethical and social implications of GenAI in aviation education (Conrad & Hall, 2023; Woods & Blickensderfer, 2024). The inquiry should consider issues of data protection and security, responsibility, and the potential role of AI in human interaction and collaboration during training events (Conrad & Hall, 2001; Woods & Blickensderfer, 2006). Research must provide guidance around ethical principles and best practices for the responsible implementation of GenAI into aviation educational programs, to ensure ethical use while realizing its benefits (Conrad & Hall, 2023; Woods & Blickensderfer, 2024). For instance, as part of creating protocols that address the identification of bias, training programs and opportunities are fair and just (Conrad & Hall, 2023; Woods & Blickensderfer, 2024). The ethical implications of responsible AI development and use should be proactively reviewed.

RESULTS AND DISCUSSION

Several key findings indicate that while GenAI holds the promise of transformative capabilities, it also presents substantial challenges to the field.

Pedagogical Approaches

The literature offers diverse innovative educational methods utilizing GenAI that can be applied to improve aviation education. A specific method is personalized learning and adaptive learning, where GenAI customizes training material to the students based on their own needs for further involvement and knowledge retention (Noroozi *et al.*, 2024; Yusuf *et al.*, 2024). Not only does this sort of learning environment sustain motivation, but it also provides the possibility of developing tailored flight simulation scenarios that closely meet students' challenged needs (Noroozi *et al.*, 2024; Yusuf *et al.*, 2024). One of the most significant discoveries is that GenAI can produce highly realistic weather patterns and emergencies to allow students to practice challenging skills in a risk-free manner (Noroozi *et al.*, 2024). AI-prompted tutoring systems have also been identified as a key integration that allows for immediate feedback and support that is beneficial for learning (Wang *et al.*, 2024).

Learning Outcomes

Results of this review suggest that there is a marked difference in educational effectiveness due to the integration of GenAI into aviation training. Research has indicated better skill procurement, more information keeping, and better performance over students using GenAI-powered platforms (Mittal *et al.*, 2024). But even if the literature indicates positive effects, it gives a clear sign for more experimental studies to capture them in a holistic way (Mittal *et al.*, 2024; Woods & Blickensderfer, 2024). Notably, the potential of pilots having increased safety and better decision-making by gaining advanced situation awareness from GenAI simulation has been highlighted as an important aspect of research (Elanjeran *et al.*, 2024).

Cost Efficiency and Accessibility

The findings indicated that GenAI promised to significantly improve efficiency and lower the cost of flight training by automating processes like assessment and feedback. This enables teachers to concentrate on individual tutoring (Matthew *et al.* 2023). Furthermore, the cost-effectiveness of digitized tools is likely to promote equal opportunity in quality aviation education, particularly for remote-area and disabled students (Ahmed *et al.*, 2024; Wang *et al.*, 2024). The access to education is also improving, by diversifying the learning experiences offered to students (Wang, 2024).

Challenges and Limitations

In spite of the encouraging results, there are many challenges which must be overcome in order to accomplish successful integration of GenAI. Academic integrity issues are particularly concerning, where students could potentially cheat by using GenAI to produce assignments or exam responses and impact assessment efforts (Ponte & Dwyer, 2024; Seo *et al.*, 2024). Furthermore, AI bias in the outputs of AI may raise ethical issues which might cause unfairness to occur in aviation training (Conrad & Hall, 2023). Another key problem is the risk of relying to a large extent on technology, making it a barrier for critical

thinking and problem-solving for aviation professionals (Stankovski *et al.*, 2024).

Future Research Directions

This analysis calls for more studies in several categories to confirm GenAI effects in aviation training. This will involve controlled experimental studies to compare the training performance of GenAI against traditional methods (Uppin & Madalgi, 2023). Working on biases in AI systems and on sustainable pedagogical concepts in integrating GenAI into education is also of crucial importance (Kuka & Sabitzer, 2024; Wu *et al.*, 2022). The importance of ethical considerations and actionable steps to guarantee data privacy and security has been recommended (Mallam *et al.*, 2019; Renganayagalu, 2019). In conclusion, Generative AI in aviation training presents a historic opportunity to transform the industry by putting the tools and knowledge in the hands of the next generation of professionals who will be expected to fly and maintain safe, reliable, and efficient aircraft. By utilizing the combined power of GenAI and other cutting-edge technology, like VR and AR, educators will undoubtedly be able to provide new levels of student engagement that immerse, personalize, and educate like never before. Yet harnessing such transformative potential does not solely rest on the technology at hand but the ethical, innovative, and evidence-based strategies by which they are implemented. Overcoming obstacles like academic dishonesty, the constraints of technology, and the requirement to raise AI literacy will prepare the aviation industry to deliver a future where experts and AI work side-by-side doing what each does best, generating professionals who are both skilled in their fields and who are also flexible, ethical, and ready to keep global aviation safe and efficient.

CONCLUSION

Generative AI has the potential to revolutionize aviation training, customized learning experiences, interactive simulations, and learning assessment modalities (Noroozi *et al.*, 2024; Woods & Blickensderfer, 2024). Although promising, the potential of GenAI in aviation training is still very much under-conceptualized. The long-term impact of GenAI tools' impacts on learning outcomes needs to be examined in deeper detail in future research (Kuka & Sabitzer, 2024; Noroozi *et al.*, 2024). Longitudinal studies are needed to determine the long-term effect of activity integration of GenAI on students' performance, retention of learned knowledge, and skill development (Kuka & Sabitzer, 2024; Noroozi *et al.*, 2024). About the effectiveness of (teaching methods) pedagogical approaches and implementation of best practices for the integration of GenAI within aviation training programs could also be researched (Kuka & Sabitzer, 2024; Noroozi *et al.*, 2024). In addition, future research must focus on creating and testing appropriate ethical frames for using GenAI responsibly in aviation education (Noroozi *et al.*, 2021; Wang, N. and S. *et al.*, 2020). This includes the examination of AI-generated content for bias, creation of measures to counterbalance such bias, as well as to clarify how data privacy is handled and how intellectual property rights are guaranteed (Noroozi *et al.*, 2024; Wang *et al.*, 2024). In addition, it remains for future research to investigate how the GenAI system can be combined with other educational technologies like VR and AR (Mallam *et al.*, 2019; Wu *et al.*, 2022). GenAI and immersive technologies when combined can provide effective learning environments (Mallam *et al.*, 2019; Wu *et al.*, 2022) which could be very engaging. Nevertheless, more studies are needed to explore the best approaches to incorporate these technologies and to examine their effects on students' learning effectiveness (Mallam *et al.*, 2019; Wu *et al.*, 2022).

In summary, the integration of Generative AI into aviation training represents a groundbreaking opportunity to revolutionize the field, equipping future professionals with the skills, knowledge, and adaptability required for a dynamic and safety-critical industry. GenAI combined with other advanced technologies such as VR and AR, further enhances the experience for the educator, enabling them to develop an exclusive, personalized, and effective learning environment. However, the true potential of this transformation lies not only in the technology itself but also in the commitment to ethical, innovative, and well-researched implementation strategies. By addressing challenges such as academic integrity, technological limitations, and the need for AI literacy, the aviation industry can embrace a future in which human expertise and artificial intelligence work in harmony. This balanced approach has the power to cultivate a workforce that is not only highly skilled but also adaptable, ethical, and prepared to ensure the safety and efficiency of global aviation operations.

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