İSTANBUL UNIVERSITY PRESS

Human Factors in Aviation and Aerospace
HFAA 2025, 2 (1): 27–36

https://doi.org/10.26650/hfaa.2025.1664457

Submitted | Başvuru 15.03.2025
Revision Requested | Revizyon Talebi 15.04.2025
Last Revision Received | Son Revizyon 16.04.2025
Accepted | Kabul 16.04.2025

Human Factors in Aviation and Aerospace

Research Article | Araştırma Makalesi

Open Access | Açık Erişim

Scenario-based learning to promote active learning among Airline Pilots

Havayolu Pilotları Arasında Aktif Öğrenmeyi Teşvik Etmek İçin Senaryo Tabanlı Öğrenme

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Abstract Scenario-Based Learning (SBL) is an instructional methodology that fosters active learning by incorporating practical and organizational experience into the classroom environment. This study aims to explore airline pilots' perceptions of SBL in the context of operational procedures. To the best of the authors' knowledge, no prior research has specifically examined how Scenario-Based Learning (SBL) can enhance active learning, improve situational awareness, and mitigate the risk of human error in high-pressure aviation environments. A 30-item survey was administered online following the completion of 18 hours of classroom-based training. The survey included demographic questions, 14 items related to SBL, 9 items concerning non-technical skills, and 3 items from the safety perception scale. Using empirical analysis, the study investigated the relationship between SBL and non-technical skills. The results indicate that the most significantly enhanced non-technical skills through participation in the SBL-integrated course were application of knowledge, analytical thinking, problem-solving, and decision-making. These findings offer important insights into the integration of SBL within aviation training programs, highlighting its potential to foster a safer and more effective cockpit culture.

Öz Senaryo Tabanlı Öğrenme (SBL), pratik ve örgütsel deneyimleri sınıf ortamına dahil ederek aktif öğrenmeyi teşvik eden bir öğretim metodolojisidir. Bu çalışma, havayolu pilotlarının operasyonel prosedürler bağlamında SBL'ye yönelik algılarını incelemeyi amaçlamaktadır. Yazarların bilgisi dâhilinde, daha önce hiçbir araştırma, Senaryo Tabanlı Öğrenme'nin (SBL) yüksek baskı altındaki havacılık ortamlarında aktif öğrenmeyi nasıl artırabileceğini, durumsal farkındalığı nasıl geliştirebileceğini ve insan hatası riskini nasıl azaltabileceğini özel olarak incelememiştir. 18 saatlik sınıf ortamında verilen eğitimin tamamlanmasının ardından çevrimiçi olarak 30 maddelik bir anket uygulanmıştır. Anket, demografik soruların yanı sıra, SBL ile ilgili 14 maddeyi, teknik olmayan becerilere yönelik 9 maddeyi ve güvenlik algısı ölçeğinden 3 maddeyi içermektedir. Ampirik analiz yoluyla bu çalışmada, SBL ile teknik olmayan beceriler arasındaki ilişki araştırılmıştır. Sonuçlar, SBL entegrasyonuna sahip eğitime katılımın en fazla geliştirdiği teknik olmayan becerilerin bilgi uygulama, analitik düşünme, problem çözme ve karar verme olduğunu ortaya koymuştur. Bu bulgular, SBL'nin havacılık eğitim programlarına entegrasyonuna ilişkin önemli bulgular sunmakta ve daha güvenli ve etkili bir kokpit kültürü oluşturma potansiyelini vurgulamaktadır.

Keywords Scenario-based learning · active learning · Non-technical skills · safety · airline pilots · aviation

Anahtar Kelimeler Senaryo tabanlı öğrenme · aktif öğrenme · teknik olmayan beceriler · emniyet · havayolu pilotları · havacılık

Citation | Atıf: Kara Arseven, G., Öztopal, S. E. & Kılıç, B. (2025). Scenario-based learning to promote active learning among Airline Pilots. *Human Factors in Aviation and Aerospace*, *2*(1), 27-36. https://doi.org/10.26650/hfaa.2025.1664457

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Scenario-based learning to promote active learning among Airline Pilots

In the aftermath of a series of high-profile incidents, flight safety has once again returned to the forefront of public attention (Cheetham et al., 2025). The number of accidents increased during the past two months (January and February 2025) (Knox, 2025). It is an undeniable fact that the majority of aviation accidents are predominantly attributed to human factors, including situational awareness, knowledge application, decision-making, and related competencies (Bilal Kilic, 2019, 2020; Bilal Kilic & Gumus, 2020; Bilal Kilic & Soran, 2019).

Knowledge is an indispensable element in ensuring flight safety (Havle & Kılıç, 2019)(Bilal Kilic & Soran, 2020). It forms the foundation upon which sound decisions, accurate judgments, and effective responses to in-flight challenges such as emergencies, are built. From understanding aircraft systems, operational procedures, and meteorological conditions to interpreting rules and regulations and recognizing human factors, pilots and aviation professionals depend on continuous learning to uphold the highest safety standards (Bilal Kilic, 2024) (Şenol & Acar, 2020). Without comprehensive and up-to-date knowledge, even the most experienced flight deck crew members can become vulnerable to errors. Therefore, ongoing education, training, and information-sharing are essential to sustaining a strong safety culture in aviation(Bilal Kilic & Buyuksoy, 2022; Bilal Kilic & Soran, 2020)(Bilal Kilic, 2021c).

Non-technical skills are the cognitive, social, and personal resource skills that complement technical proficiency and contribute to safe and effective performance in complex operational environments (Çeken & Beyhan Acar, 2025)(Ceken, 2024). The development and effective application of non-technical skills among airline pilots such as communication, decision-making, situational awareness, teamwork, and workload management, are closely associated with their underlying knowledge base (Bilal Kilic, 2021a, 2021b, 2022; Bilal Kilic & Tabak, 2022). While non-technical skills are often classified separately from technical competencies, their successful execution depends heavily on a pilot's cognitive understanding of aircraft systems, procedures, operational environments, and human performance limitations (B. Kilic & Ucler, 2019)(Ozturk, 2020). For instance, making timely and effective decisions during abnormal operations requires not only sound judgment but also comprehensive knowledge of available options and their implications. Similarly, maintaining situational awareness depends on interpreting and integrating diverse sources of information, an ability rooted in both training and theoretical understanding.

Scenario-Based Learning (SBL) offers a significant advantage over classical tutorial teaching methods by actively engaging learners in realistic, context-rich situations that mirror the complexities of real-world operations (Salas et al., 1998) (Clark & Mayer, 2016). While traditional tutorials often rely on passive absorption of information through lectures or step-by-step instruction, SBL promotes critical thinking, decision-making, and problem-solving by placing learners in dynamic scenarios where they must apply their knowledge and skills (Rashwan, 2023). This immersive approach enhances retention, builds confidence, and better prepares individuals for unexpected events . In aviation training, for example, SBL helps bridge the gap between theoretical understanding and practical execution, fostering deeper comprehension and improved performance in safety-critical environments (Cox, 2010). As a result, SBL not only enhances comprehension and retention but also cultivates the cognitive flexibility and situational awareness for airline pilots. SBL scenarios help airline pilots better understand the decisions they have to make during the daily flight operation. Scenario-Based Learning (SBL) enhances airline pilots' ability to concentrate on the decision-making process and its potential consequences.

Although extensive research has been conducted on Scenario-Based Learning (SBL) in various high-reliability industries such as medicine, no study to date has specifically investigated its learning-enhancing impact among airline pilots. With this in mind, the present study aims to analyze the implementation of SBL in the context of airline pilot training.

Materials and Methods

Study design

In this study, scenarios were developed that would allow pilots to reinforce their knowledge and achieve deeper learning by applying what they know about operational procedures. In this 18-hour study, during each hour, a sample scenario covering flight operations was presented to the participants. Following the presentation, an interactive brainstorming session was conducted, during which the errors, violations, and correct actions within the scenario were discussed within the framework of operational manuals. One of the scenarios discussed during the session is as follows: "*You and your colleague are reviewing the flight folder at the Dispatch Office. The estimated time of arrival is 22:15 UTC. The current weather and forecast for the destination airport are as follows: METAR 051700Z 10002MPS CAVOK 16/07 Q1031 R06/000065 NOSIG=*
TAF 051354Z 0515/0615 09003MPS 9999 SCT030 TX23/0612Z
TN08/0603Z PROB30 0522/0605 0300 FG BKN002=

1. *Can this flight be dispatched based on the weather reports provided above?*
2. *Is additional (allocated) fuel required?*

During the flight, the flight deck crew receives an ACARS message indicating that the prevailing wind for Runway 19 is from 280 degrees at 19 knots, gusting to 29 knots, with moderate rain showers. Additionally, the Rescue and Fire Fighting Services (RFFS) category at the destination airport has been downgraded to Category 5. The captain makes the following decision:
"Given the prevailing conditions, we need to divert to destination alternate airport." What would your decision be under these conditions?

Participants were required to examine the scenario and assess it with reference to their respective operations manuals. Following the completion of the scenario-based sessions, a questionnaire consisting of 30 items was presented to the participants. The survey was derived from the previously published studies (Mio et al., 2019) (Tunç & Kilic, 2024) and was administered online to 100 airline pilots currently active in airlines across Türkiye. These 100 first officers were selected through a randomized sampling method to ensure representativeness and reduce potential selection bias, and all had participated in the SBL training sessions. The questionnaire consisted of four sections: (i) demographic information, (ii) scenario-based learning (SBL), (iii) non-technical skills, and (iv) safety perception. The response rate was 71%. Participation was voluntary and anonymous. All respondents were first officers. Among the participants, 63 (88.7%) were male and 7 (11.3%) were female. Approximately, two-thirds of the participants had less than 5 years of flight experience. All participants (100%, *N*=71) operated short-haul aircraft (e.g., Boeing 737NG and MAX and Airbus 319/320/321). In terms of age distribution, 31% of those who were interviewed (*N*=22) were between 20-30 yr of age, 47% (N=66) of the participants were 31–40 yr of age, and 3% (N=2) of the subjects were over 40 years old. Ethical approval for the study was obtained from the Özyeğin University's Human Research Ethics Board (2025/04/03-BİLAL KILIÇ).

Table 1

Frequencies of Demographic Variables

Variables	Categories	Frequencies	Percent
Age	20-30	22	31
	31-40	47	66
	41 and above	2	3
Experience	Less than 5 years	63	89
	5 to 10 years	8	11
Monthly Flight Hours	Up to 60 hours	53	75
	61-70 hours	16	22
	71-80 hours	2	3

Statistical analysis

Data for this study were collected from 71 airline pilots on general demographics including gender, age, and flying hours using an online questionnaire. The analysis was performed using the SPSS 25.0 package. In order to test the reliability of the 3 expressions (safety perception) in this study, Cronbach's alpha analysis was carried out (George & Mallery, 2019). Statistical significance was analyzed using t-tests and analysis of variance (ANOVA) test as appropriate. The descriptive statistics are presented as frequency, percentage, mean, and standard deviation. Statistical significance was analyzed using t-tests and analysis of variance (ANOVA) test as appropriate.

P values less than 0.05 were considered statistically significant in the study ($\alpha = 0.05$) (George & Mallery, 2019).

Result and Discussion

The findings indicated that integrating scenario-based learning (SBL) into the instructional environment fostered active learning among airline pilots. Table 2 demonstrates that the highest mean scores on the scale measuring the perceived benefits of SBL correspond to the integration of real-life elements, the enhancement of the overall learning experience, and the alignment of course content with operational practice. The results also indicated a preference for the use of scenarios over traditional tutorial problems. Another noteworthy finding of this study is that participants expressed a desire for scenarios to be incorporated as a learning resource in other training formats, such as recurrent training and e-learning courses.

Table 2

Rankings of the Perceived Benefits of Scenario-Based Learning (SBL)

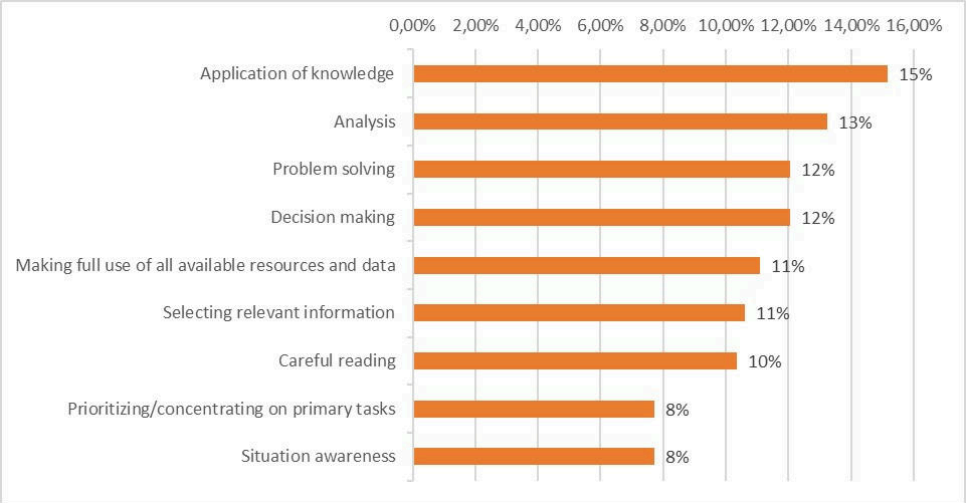
Item	Min	Max	Mean	Standard Deviation
I enjoyed the scenario because it had a real-life component	1	5	4,51	0,67
The scenario enhanced my learning in this class	1	5	4,48	0,65
The scenario helped me to see connections between lecture content and operational procedures	1	5	4,46	0,67
The scenario helped me to consolidate my understanding of the class content	1	5	4,45	0,67
The scenario is an engaging way of supporting the learning of the class material	1	5	4,39	0,69
Doing the scenario was an enjoyable learning experience	1	5	4,39	0,73

Item	Min	Max	Mean	Standard Deviation
I found the use of the scenario a helpful way of improving my problem-solving skills	1	5	4,38	0,7
As a result of doing the scenario, I am now interested in finding more about relevant operational procedures	1	5	4,3	0,8
I prefer the use of scenarios more than tutorial problems	1	5	4,28	0,88
My ability to analyze problems and situations improved as a consequence of doing the scenario exercise	1	5	4,28	0,68
In order to proceed through the scenario, I had to reflect on what I knew	1	5	4,27	0,76
My problem-solving skills were improved as a consequence of doing the scenarios	1	5	4,23	0,74
In order to proceed through the scenario, I had to learn new concepts	1	5	4,17	0,76
I would like other classes (recurrent/e-learning) to use scenarios as a learning resource	1	5	3,62	1,09

Additionally, participants were asked to evaluate which non-technical skills they believed had improved through the use of SBL. The results presented in Figure 1 indicate that 89% of participants found SBL to be beneficial for the **application of knowledge**. Furthermore, 77% selected **analysis**, while 70% identified both **problem-solving** and **decision-making** as non-technical skills that had been enhanced through the SBL approach.

Figure 1

Participants' Evaluation of Improved Non-Technical Skills through Scenario-Based Learning (Multiple selections allowed)



The results were also examined in relation to safety perception. A Pearson correlation analysis was conducted to investigate the relationship between perceived improvements in non-technical skills and participants' perceived control over safety-related occurrences. The analysis revealed a significant negative correlation between the non-technical skill **"making full use of available resources and data"** and safety perception ($r = -.387$, $p < .001$). This suggests that participants who believed they had improved their ability to gather and utilize all available data during SBL sessions were also more likely to believe that safety occurrences are not inevitable and can be prevented.

Table 3
Descriptive Statistics for the Safety Perception Scale

Item	Min	Max	Mean	Standard Deviation
You believe accidents will happen no matter what anyone does.	1	5	2,61	1,14
Staff believes that luck plays a major role in aviation safety.	1	5	2,13	1,01
You believe everyone is likely to have an accident sooner or later.	1	5	2,37	1,12

Conclusion

The main aim of this study is to determine the impact of the SBL on pilots' knowledge levels when used in theoretical instruction, as well as to examine its relationship with non-technical skills and safety perception. One of the most significant findings of the current study is that the use of SBL in theoretical knowledge training has a positive impact on "application of knowledge", which is one of the pilots' non-technical skills.

The findings of this study will make a significant contribution to the existing literature on the use of SBL in aviation. The use of SBL in the learning and reinforcement of theoretical knowledge has been shown to have positive association with the participants' non-technical skills, particularly in areas such as application of knowledge, analysis, decision making and problem solving.

It is conceivable that various limitations may impacted the outcomes of the study. Firstly, the proposed approach is applicable solely to the specific sample of airline pilots involved in the study. It may only serve as a framework for examining the impact of scenario-based learning (SBL) among student pilots if the future research extends its application to the theoretical knowledge courses, such as those for the private pilot license (PPL) or airline transportation pilot license (ATPL). For future research, the proposed model is intended to be applied within a cross-regional context. Furthermore, the reliability of the findings could be enhanced by conducting pre-tests and post-tests with participants ranging from newly graduated first officers to experienced captains.

Airline flight training departments, flight training organizations, university aviation faculties, and subject matter experts (SME) may incorporate SBL into their curricula and recurrent training programs to foster active, effective learning among pilots and to strengthen overall flight safety.

Ethics Committee Approval	The study protocol received ethical approval from the Özyeğin University's Human Research Ethics Board (2025/03/04)
Informed Consent	Informed consent was obtained from the participants.
Peer-review	Externally peer-reviewed.
Author Contributions	Conception/Design of study: G.K.A., S.E.Ö., B.K.; Data Acquisition: G.K.A., B.K.; Data Analysis/Interpretation: G.K.A., B.K.; Drafting Manuscript: B.K., G.K.A.; Critical Revision of Manuscript: G.K.A., S.E.Ö., B.K.; Final Approval and Accountability: G.K.A., S.E.Ö., B.K.
Conflict of Interest	The authors have no conflict of interest to declare.
Grant Support	The authors declared that this study has received no financial support.

Etik Kurul Onayı	Bu çalışma Özyeğin Üniversitesi İnsan Araştırmaları Etik Kurulu'ndan alınmıştır. (2025/03/04)
Bilgilendirilmiş Onam	Katılımcılardan bilgilendirilmiş onam alınmıştır.
Hakem Değerlendirmesi	Dış bağımsız.
Yazar Katkısı	Çalışma Konsepti/Tasarımı: G.K.A., S.E.Ö., B.K.; Veri Toplama: G.K.A., B.K.; Veri Analizi /Yorumlama: G.K.A., B.K.; Yazı Taslağı: B.K., G.K.A.; İçeriğin Eleştirel İncelemesi: G.K.A., S.E.Ö., B.K.; Son Onay ve Sorumluluk: G.K.A., S.E.Ö., B.K.
Çıkar Çatışması	Yazarlar çıkar çatışması bildirmemiştir.
Finansal Destek	Yazarlar bu çalışma için finansal destek almadığını beyan etmiştir.

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Appendix | Ek

Survey

Demographics

1. Gender
2. Which of the following categories describes your age?
3. How long have you been flying?
4. How many hours do you usually fly in a month?

Section 1

5. I prefer the use of scenarios more than tutorial problems
6. I would like other classes (recurrent/e-learning) to use scenarios as a learning resource
7. The scenario is an engaging way of supporting the learning of the class material
8. I enjoyed the scenario because it had a real-life component
9. Doing the scenario was an enjoyable learning experience
10. The scenario enhanced my learning in this class
11. The scenario helped me to consolidate my understanding of the class content
12. As a result of doing the scenario, I am now interested in finding more about relevant operational procedures
13. The scenario helped me to see connections between lecture content and operational procedures
14. I found the use of the scenario a helpful way of improving my problem-solving skills
15. In order to proceed through the scenario, I had to learn new concepts
16. In order to proceed through the scenario, I had to reflect on what I knew
17. My ability to analyze problems and situations improved as a consequence of doing the scenario exercise
18. My problem-solving skills were improved as a consequence of doing the scenarios

Questions of the SBL scale were to be answered on a 5-point Likert-type scale (1. Strongly disagree– 5. Strongly agree)

Section 2

From the list below select the thing(s) that you developed by doing the scenario (one or more options):

19. Problem solving
20. Analysis
21. Application of knowledge
22. Careful reading
23. Selecting relevant information
24. Decision making
25. Prioritizing/concentrating on primary tasks
26. Making full use of all available resources and data
27. Situation awareness

Section 3

Please respond to each item by marking the option that fits for you

28. You believe accidents will happen no matter what anyone does.
29. Staff believes that luck plays a major role in aviation safety.

30. You believe everyone is likely to have an accident sooner or later.

Questions of the Safety perception scale were to be answered on a 5-point Likert-type scale (1. Strongly disagree– 5. Strongly agree)