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Selection and Implementation of Evidence-Based Safety Performance Indicators in Aviation Training

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ABSTRACT

Safety management in Aviation training is shaped by identification, evaluation, and measurement of the safety risks. The International Air Transportation Authority (IATA) Technology Roadmap (IATA 2022) offers a synopsis and evaluation of ongoing technology opportunities, which change the aviation environment with the implementation of Artificial Intelligence (AI) and introduction of enhanced Minimum Crew Operations (eMCO) and Single Pilot Operations (SiPO). Change management (airplane design philosophy /ergonomics) affects aviation training design philosophy. A hybrid competency-based education approach in aviation needs interaction with the aviation industry and changes in flight operations (ICAO, 2022). The performance gap of these changes concerning the aviation industry, flight operations, and training is assessed and measured through Evidence-Based Training (EBT) pilot competencies (ICAO, 2016). Safety management systems (SMSs) in aviation training present a lag in identifying and implementing Safety Performance Indicators (SPIs). Implementation of Evidence-based Safety performance indicators as conceptualized in the aviation training through SPI's (data-based parameters from students' flights) at a theoretical and practical level, act as safety (SMS), personal development (identify pilot weakness –Human Factors), and assessment (Competency-based education) tool (ICAO, 2018).

Keywords: Evidence-based training (EBT), Safety management systems (SMSs), Safety performance indicators (SPIs), Human factors (HF), ergonomics, Aviation training

INTRODUCTION

Adaptation of new technology in aviation depends on training systems design. Evidence-based Training (EBT), according to the International Civil Aviation Organisation (ICAO), develops "a new paradigm for competency-based training and assessment of airline pilots based on evidence" (ICAO, 2006). Competency-based training emphasizes new technologies (i.e., AI and ergonomics) and the identification of target interventions focusing on students' learning needs (Keller et al., 2020). In the aviation environment, among the eight critical considerations of the Competency-Based Education Network ([C-BEN] 2018), the selection of "Evidence - driven Continuous improvement" and "Collaborative Engagement with External Partners" targets, links collegiate aviation education system and the airline operational. EBT programs in airline operations rely on the maturity of the operator's safety management system (ICAO, 2016).

Safety Data Collection and Processing Systems (SDCPS) affect safety performance management maturity. Furthermore safety analysis focuses on the development of the organization's safety objectives -Safety Performance Indicators (SPIs) (Maurino, 2017). Safety objectives measurement is achieved by identifying SPIs used to monitor and measure safety performance (ICAO, 2016). Accidents, incidents, flight operations, and training data collection reviewed and updated continually validate course development Safety Performance Indicators. The lagging indicators focus on long-term trends, events that have occurred, and organization targets as prevention goals. Leading SPI's serve as a weaknesses and vulnerabilities' prediction and adaptation to changes maker tool (ICAO, 2018).

Aviation programs following a competency-based approach offer the resulting advantages: (a) aviation safety; (b) advanced training based on knowledge, skills, and abilities; (c) satisfy personnel safety standards; and (d) follow a qualitative (student learning objectives) with quantitative approach accumulating flying hours, (Keller et al., 2020). In order to measure safety risk in training based on the above-described concept, an accurate system model is necessary utilizing data-driven SPIs. SPIs must be specific, measurable, achievable, relevant, and timely oriented (SMART). The School of Aviation and Transportation Technology (SATT) at Purdue University has selected CloudAhoy data visualization and analysis technology to integrate students' flight data from multiple sources. This selected method analyzes, combines, and transforms the data into meaningful information within the safety management system's flight operations and develops an aviation training approach that utilizes an evidence-based training database from airline operators and students' flight data. The following design level focuses on implementing machine learning in students' flight data integration to SPIs. Machine Learning (ML) is a system's capability to acquire knowledge through data rather than software elaboration in a critical decision path. However, this could be considered a significant opportunity for the aviation industry to shorten development cycles (EASA, 2020).

DEVELOPING EVIDENCE-BASED SAFETY PERFORMANCE INDICATORS TO SUPPORT AVIATION TRAINING DESIGN

This study aims to present, identify and implement evidence-based Safety Performance Indicators in Aviation Training following an interpretivist philosophy on the Purdue University case study. Specifically, this study identified and examined safety performance thematic areas chosen by discrete, observational experiences related to the selected aviation university database (EBT), literature review, questionnaires, and current SPIs. Figure 1 presents the philosophical rationale that assured the adapted research method (Saunders et al., 2019).

The research followed the single case study approach. Initially, the research team apprehended the aviation university students' pilots' perceptions

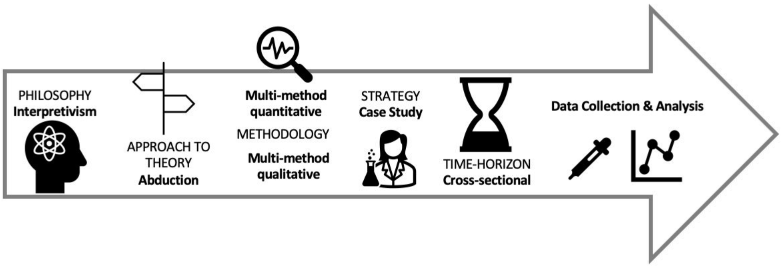

Figure 1: Research framework schematic presentation.

through an online questionnaire (Yin, 2014) and literature review under the research questions framework:

- How do students understand SPI's?
- How could the proposed SPI's introduction affect the existing safety management practices?

Through a practical and controlled analysis, the questionnaire results linked the variable indicators and acknowledged the relevance and experiences relating to the research questions and literature review findings for the SPI's (Coolican, 2019).

Following a thematic coding technique, the research team applied an analytical approach representing the flight training areas related to the research question framework. The interpretive stage followed the triangulation method (Merriam, 2015). The results of each question are linked with central themes and categorized (Coolican, 2019). Then, a frequency analysis was performed for the derived themes to assess repetition in the entirety of the group feedback and to formulate a model of the major themes and the associated responses (King and Horrocks, 2010; Merriam, 2015). This thematic code method oriented the analytical process. The yielded thematic outputs represented the consensus of the grouped responses, whereas any deviations were critically discussed and interpreted (Merriam, 2015).

In designing the aviation training, the School of Aviation and Transportation Technology at Purdue University has focused on the existing SPIs from the EBT airline operator's database, flight-training organization's SMS, and selected proposed safety indicators from SATT students flights thematic analysis. Additionally, the research team selected CloudAhoy data visualization and analysis technology to integrate students' flight data from multiple sources. This selected method analyzes, combines, and transforms the data into meaningful information within the training syllabus. Debriefs performed using CloudAhoy are used in a variety of training scenarios and mainly in the thematic analysis for the implementation of safety performance indicators of the SATT safety management system. CloudAhoy's rule-based knowledge engine uses an updated airplanes flight envelope database. Once the flight data has been collected, a structured and controlled thematic analysis - following Evidence-Based Training (EBT) criteria - compared the varying perspectives and identified the qualitative and quantitative SPIs. The analysis

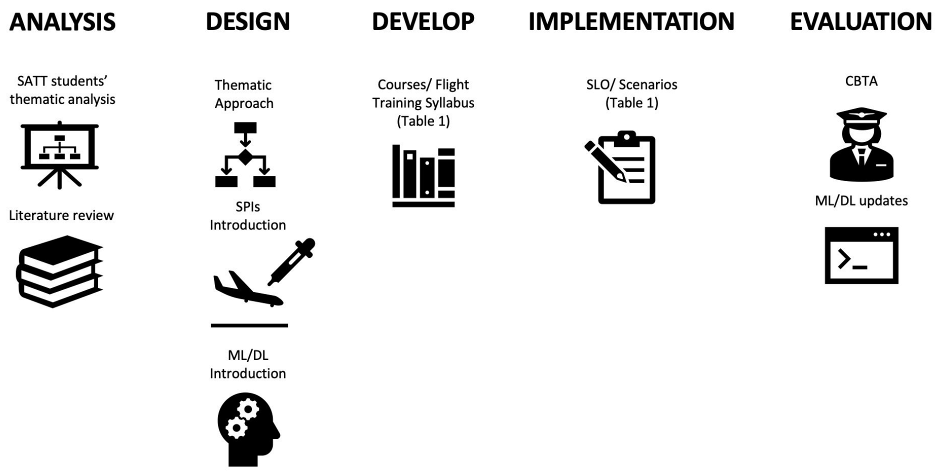

Figure 2: ADDIE approach proposal.

used multiple thematic results indicating the consent of the clustered replies, and a t-test is used as a hypothesis-testing tool, which tests any statement applicable to the population. The analysis part includes a hierarchical skills analysis which provides a bridge between the classical skills taxonomies (such as Blooms) and competencies and can be used as a practical instrument for training design focusing on Human Factors aspects (ICAO, 2006).

SPIs AS A SUPPORTIVE FRAMEWORK FOR AVIATION TRAINING DESIGN

The proposed aviation design philosophy follows the ADDIE (Analyze-Design – Develop – Implement – Evaluate) approach, implementing evidence-based safety performance indicators (SPI's) (Figure 2):

- Analyze the Flight school SMS – collected data related to EBT ICAO analysis.
- Design the areas of learning interest related to operations – evidence-based – SMS / (SPI's) – thematic approach. Introduction of ML/DL software.
- Develop the courses - learning objectives using the EBT ICAO database (national database option) – develop scenarios.
- Implement the learning objectives – scenarios.
- Evaluate using CBTA competencies as described in ICAO documents. Use of ML/DL software capabilities (EASA,2020).

IATA recommendation for aviation training is the implementation of the latest ICAO provisions for competency-based training and assessment. AOCs and ATOs should use the nine (9) Pilot competencies (eight (8) Pilot competencies as proposed by ICAO and the competency "Application of Knowledge" recommended by EASA for EBT.

Based on the current vision of Purdue University on competency-based training (Keller et al. 2020) and the evaluation of ongoing technology opportunities in aviation training, a holistic aviation training approach covers

Table 1. SPI's implementation in the Aviation training system.

CBTA competencies / SPI's	Pilot competencies	Evidence-Based Training Competencies	Purdue Collegiate Competencies
PC 0 / SPI 0	Application of Knowledge		Technical Excellence
PC 1/ SPI1	Application of Procedures and Compliance with Regulations	Application of Procedures	Technical Excellence
PC 2/ SPI2	Communication	Communication	Communication
PC 3/ SPI3	Aeroplane Flight Path Management, automation	Flight Path Management, automation	Technical Excellence
PC 4/ SPI4	Aeroplane Flight Path Management, manual control	Flight Path Management, manual control	Technical Excellence
PC 5/ SPI5	Leadership & Teamwork	Leadership & Teamwork	Leadership
PC 6/ SPI6	Problem Solving & Decision Making	Problem Solving &Decision Making	Decision Making
PC 7/ SPI7	Situation Awareness and Management of Information	Situation Awareness	Resilience
PC 8/ SPI8	Workload Management	Workload Management	Teamwork

under the six collegiate competencies, the proposed pilot competencies from ICAO / EASA/ CBTA, evidence-based SPI's (Table 1).

The suggested training concept shift under EBT should be regarded not as a mere replacement set of the outdated set of critical events but rather as the mean for developing and assessing crew performance by using human factors aspects and well-defined Safety Performance Indicators (SPI's). The thematic analysis for identifying evidence-based Safety Performance Indicators in Aviation Training and qualitative analysis of the collegiate competencies prove the dominance of human factors and ergonomics opposing the technical aspects.

To conclude, a complex learning training program should hone the more significant cognitive areas (i.e., integrated objectives) and simultaneously support nonrecurrent aspects' schematic structure and recurrent aspects' rule automation (Harris, 2011).

CONCLUSION

Safety performance measures the ability to manage safety risk in training effectively. This review assesses the selection and implementation of Safety

Performance Indicators (SPIs) in a Safety Management System and evaluates the perceptions and satisfaction of pilots at the selected case study of Purdue University School of Aviation and Transportation Technology (SATT). In order to measure safety risk in training, an accurate system model is necessary utilizing data-driven SPIs. Results of this study propose recommended practices for SPI's amalgamation at the Purdue University - SATT, and adaptation policies of how other ATOs might follow to enhance the role of SPIs. SATT uses leading and lagging SPI's as advanced markers of evidence (EBT) for selected types of incidences/accidents or locations affecting the training process.

Furthermore, leading SPIs are used to identify, monitor, and evaluate conditions that cause or contribute to a specific training outcome – student learning objective (SLO). Finally, the leading SPIs with the Competency-Based Training Assessment under ML/DL software are researched by Purdue University SATT faculty. Machine Learning (ML) is a system's capability to learn from a set of data rather than software elaboration in a critical decision path. Despite the many challenges concerning the trustworthiness of Machine Learning / Deep Learning (DL) software and its effects on aviation training – safety, this could be considered a significant opportunity for the aviation industry to shorten development cycles (EASA, 2020).

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