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CASE STUDY

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Justification and development of competencies to transform a collegiate aviation flight program

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Abstract

Background: The aviation industry is facing a substantial shortage of pilots. Per the International Civil Aviation Organization, it is projected airlines will need 350,000 pilots globally.

Aims: Due to the demand of pilots, most of the conversations are focused on quantity rather than quality of the workforce. Educators and researchers in several industries have advocated competency-based education in aviation for decades.

Method: Members of the research team documented the consensus decision-making process which determined which competencies would be incorporated into the flight program.

Results: Six competencies were selected for the hybrid competency-based education model. Teamwork, decision-making, communication, resilience, leadership, and technical excellence were extensively defined for the aviation program.

Discussion/Conclusion: Shifting toward a hybrid competency-based education model is challenging within a large flight program. However, the members of the research team believe the transformation process will improve program outcomes. Next steps include assessment plan development and data collection.

KEYWORDS

aviation safety, collegiate aviation, competencies, flight training

1 | INTRODUCTION

According to the International Civil Aviation Organization (ICAO), by 2036 the aviation sector will need 620,000 new pilots, 125,000 new air traffic controllers, and 1.3 million aircraft maintenance personnel (ICAO, 2018). Boeing's Pilot and Technician Outlook (2018) forecasts there is a need for 790,000 new pilots, 754,000 new technicians, and 890,000 new cabin crew members by 2037. However, focusing on US-based demand versus supply, it is estimated that the demand is about three times the supply (Schonland, 2016). As a result of this massive gap in supply, there is a severe pilot shortage across the nation and this issue has garnered attention from mainstream media (Garcia, 2018).

As a result, most of the national and global conversations are focused on quantity rather than quality of the workforce. Educators and researchers in several industries have advocated competency-based education for decades (Kearns, Mavin, & Hodge, 2018; Mott et al., 2019). In the aviation industry, ICAO (2013) and the International Aviation Transport Association (IATA) (IATA, 2013) have recognized the need to develop and evaluate the performance of flight crews according to a set of competencies. Interestingly, both ICAO (2013) and IATA (2013) encourage operators to identify and develop their own competency system and related behavioral indicators, encompassing the nontechnical and technical knowledge, skills and attitudes to operate efficiently, effectively, and safely in the aviation industry. This report presents Purdue University's approach to define, develop, and measure core competencies for the next generation of pilots. These competencies are intended to address the quality aspect of workforce development.

One of the challenges to building pilot supply pipeline in the United States is that pilots seeking a first officer position (a common entry-level position at Part 121 air carriers) are required to possess an Airline Transport Pilot (ATP) Certificate and 1,500 hr of total flight time. This requirement in the United States was placed in response to three high-profile accidents and with the hope that increased flight hours required would lead to increased safety (Smith et al., 2016). While there is no evidence that this unidimensional metric is a reasonable predictor of quality of pilots entering the workforce, the global aviation industry outside of the United States is moving toward evidence-based training (EBT). EBT provides rigorous assessment and assurance of pilot competencies throughout their training, regardless of the accumulated flight hours (ICAO, 2013). Also, there is some emergent empirical evidence that high-quality education and flight training have more impact on efficiency and safety than just the total flight hours accumulated by entry-level pilots (Smith et al., 2017).

Aircraft design and reliability as well as pilots' education and training have steadily and significantly improved in the last 20 years. Nevertheless, high-profile accidents still occur, even when the aircraft and related systems are adequately operating. Controlled Flight Into Terrain (CFIT) and Loss of Control in Flight (LOC-I) are examples of mishaps in which inadequate decision-making, poor leadership and teamwork, and ineffective communication are frequently cited as contributing factors. Conventional flight training requirements generally "consider only the so-called "technical skills" and knowledge" (ICAO, 2013, p. 5). Interestingly, pilot's competencies in important areas, such as leadership, resilience, and communication, are not addressed. ICAO (2013) defines competency as a "combination of knowledge, skills and attitudes required to perform a task to the prescribed standard" (p. xi). It is unrealistic to foresee all possible aircraft accident scenarios.

According to IATA (2013), the aviation system is reliable but complex. Additionally, there are many organizational variables that could have a detrimental impact in the flight deck of an aircraft. The complexity and reliability of the aviation system associated with a multitude of organizational factors could mean that future accidents may be something unexpected. Conversely, competencies such as teamwork and resilience will allow flight crews to manage previously unseen potentially dangerous situations in flight. The development of technical and nontechnical competencies is an important safety improvement initiative.

However, due to the current regulatory requirements of the Federal Aviation Administration (FAA), the hours-based approach and aeronautical experiences ultimately guide the curriculum and the flight certification process (FAA, 2007). Additionally, learning outcomes are guided by the Aviation Accreditation Board International (AABI) (AABI, 2017). Despite the regulations and accreditation standards, and considering the benefits of a competency-based program as described by ICAO (2013), IATA (2013), and Mott et al., (2019), the flight faculty of Purdue University and the Industry Advisory Board (IAB) for the professional flight program engaged in a series of meetings since the summer semester of 2018. The purpose of those meetings was to identify and describe a set of core and sub-level competencies that will constitute the framework for the professional flight program.

To satisfy the current academic requirements, the authors aimed toward a hybrid competency-based education approach. According to the Council of Regional Accrediting Commission (C-RAC) (2015), "the hybrid approach, combines the course-based approach and the direct assessment approach. Hybrid programs allow students to complete a degree or credential through a combination of direct assessment of competencies and credit hours" (p. 3). To develop the competencies, researchers of this paper utilized the consensus decision-making approach, as explained in the methodology section of this manuscript. The following section will outline the primary attributes of developing competencies for higher education programs.

2 | LITERATURE REVIEW

2.1 | Current status of competency-based education in the United States

Competency-based education (CBE) programs have continued to increase throughout higher education (Kelchen, 2015). According to the American Institutes for Research ([AIR], 2019), there has been slow but steady development and implementation of competency-based education in America. The 2019 survey results revealed that 509 institutions were interested, in the process of implementing, or currently have a CBE program (AIR, 2019). Though the concept has been around for more than 50 years, it is still considered a nascent field (Competency-Based Education Network, 2020).

In comparison with traditional education models including online programs, the total numbers of CBE programs, many of which are pilots, remain small. Nonetheless, other metrics also suggest that CBE planning and development is increasing. Webinars, conferences, workshops, and working groups have pooled CBE development and implementation as well as introduced faculty, administrators, and student services staff to competency-based approaches. Additionally, private foundations such as the Spencer Foundation have provided grant support to better understand and share the findings of innovative education programs (Spencer Foundation, 2019). *The Journal of Competency Based Education* is also another measure of the rising prominence that CBE has gained more traction in higher education. Furthermore, the US Department of Education (n.d.) has supported CBE and has the following statement:

> Transitioning away from seat time, in favor of a structure that creates flexibility, allows students to progress as they demonstrate mastery of academic content, regardless of time, place, or pace of learning. Competency-based strategies provide flexibility in the

> way that credit can be earned or awarded and provide students with personalized learning opportunities.
>
> (p.1)

However, there have been notable challenges regarding CBE. In addition to the various models of CBE, there has not been a consensus of what CBE is. Even the term CBE is up for debate. For example, mastery-based education, performance-based education, standards-based education, and proficiency-based education can be interchanged and or have a different meaning depending on the discipline as well as context. Nevertheless, guidance from leaders in CBE has begun to sort through the entanglement. The Competency-Based Education Network ([C-BEN] 2018) developed a framework for institutions to utilize during the development, implementation, and continuous improvement process. C-BEN (2018) lists eight key considerations. These key considerations are:

1. Demonstrated Institutional Commitment to and Capacity for CBE Innovation.
2. Clear, Measurable, Meaningful, and Integrated Competencies.
3. Coherent, Competency, Driven Program, and Curriculum Design.
4. Credential Level Assessment Strategy with Robust Implementation.
5. Intentionally Designed and Engaged Student Experience.
6. Collaborative Engagement with External Partners.
7. Transparency of Student Learning; and
8. Evidence-Driven Continuous Improvement (p. 4–18).

The professional flight program at Purdue University and the development process is supported by the college and University. Purdue University's Board of Trustees approved the transformation of the Polytechnic Institute in which the professional flight program resides. The goal of the transformation process focuses on innovative learning methods, hands-on experiences, and industry partnerships (Purdue University, 2019). With enough support, Flight Faculty at Purdue University were able to proceed to the second and third consideration listed above.

According to the US Department of Education (USDOE) (United States Department of Education, 2002), “competencies are the result of integrative learning experiences in which skills, abilities, and knowledge interact to form bundles that have currency in relation to the task for which they are assembled.” (p. 7). The USDOE states competency development must have three distinct yet interactive elements:

1. A description of the competency.
2. A means of assessing the competency; and
3. A standard by which a student is judged to be competent (p. 9).

The purpose of the curricular redesign is to move Purdue's undergraduate professional pilot degree program beyond accreditation and regulatory requirements and create a truly world-class program that exceeds global quality standards. According to the Flight Safety Foundation (2018), the aviation industry should not rely on the successful ways of the past but be audacious and courageous in its pursuit of the needed changes. Early efforts to use a competency-based approach to develop the knowledge requirements, develop assessment tools, and run preliminary tests support the notion that a competency-based approach could (a) identify weaknesses in pilot candidates and (b) enable hiring airlines and training providers to improve the success rate in the initial training, thereby simultaneously addressing both quality and quantity aspects of the pilot shortage problem (Patankar & Wacker, 2015a, 2015b; Patankar, Wolfe, Castle, & Lima, 2015).

Thus, a competency-based collegiate professional flight degree program could yield the following advantages: (a) significantly enhance aviation safety; (b) establish advanced training processes that will enhance the acquisition of knowledge, skills, and abilities; (c) meet or exceed personnel safety standards; and (d) emphasize quality of education and flight training over flight hours. In addition, it will develop empirical data to inform decision-makers like the US Congress, the FAA, Part 121 airlines, and aviation curriculum designers with respect to the establishment of minimum quality and performance standards for entry-level airline pilots. It is also possible that the competency-based approach could help reduce costs associated with flight training. The next section will discuss the method and procedures.

3 | METHOD

A consensus modeling approach was utilized to facilitate the process of developing the competencies described herein. Consensus decision-making refers to all members of a group agreeing on the chosen tasks, in this case competencies (Michie et al., 2005). A high level of participation among both the faculty and industry representatives, all leaders in their respective areas, was obtained. The first task of the faculty was to conduct a thorough literature review and identify 10 competencies. Once the 10 competencies were identified, focus groups and discussion were completed. These groups were a mix of faculty, flight instructors, limited term lecturers, and IAB. The IAB consisted of professional pilots and executives from airlines and the corporate flying sectors. Typically, the IAB has five–eight members and they are invited to meet in person twice a year for two working days. These sessions include presentations of curriculum initiatives, status of the industry, discussions pertaining to success of graduates, and participation in the annual poster symposium. The poster session is a requirement for graduating seniors in which they present their capstone projects. The IAB acts as judges, determines the awards, and provides feedback to faculty. Additionally, sessions were held with faculty from the other majors within the School: Aviation Management, Aeronautical Engineering Technology, and Unmanned Aircraft Systems. This provided an opportunity to obtain additional perspective.

Once all of the input from the various sessions was understood, it was apparent the goal of the faculty was to write the competencies so that assessment in the classroom, flight, and simulators was feasible. After a working draft was established, the flight faculty team sought an outside representative from a university that focuses on abilities-based curriculum for feedback. Some competencies were combined (e.g., intercultural and teamwork) leading to six pilot competencies in technical and nontechnical areas. The external expert concurred with the selected and defined competencies. The results section outlines the unanimously selected competencies, description, behavioral indicators, and rationale, as well as broad outline of the assessment strategies.

4 | RESULTS

According to US Department of Education (2018), a competency-based program leads to better student engagement because the content is relevant and tailored to each student's unique needs. Other benefits of a competency-based program include more efficient use of technology, identification of target interventions to meet specific learning needs of students, increased productivity and reduced costs, and the incorporation of active learning strategies into the curriculum (Ebert & Fox, 2014). Additionally, a competence-based program can help enhance the efficiency and safety of the aviation industry. Nevertheless, development and assessment of defined competencies can lead to better education and flight training outcomes.

In this context, and consistent with the mission of the professional flight program, both technical and nontechnical competencies were identified through extensive literature review. The six program competencies are as follows:

1. Technical Excellence.
2. Communications.
3. Leadership.
4. Decision-Making.
5. Resilience; and
6. Teamwork.

The professional flight program seeks to develop these competencies within an integrated, high-consequence, and meaningful educational environment. Figure 1 illustrates how technical excellence is at the center of our educational competencies. However, all competencies are connected and influence each other.

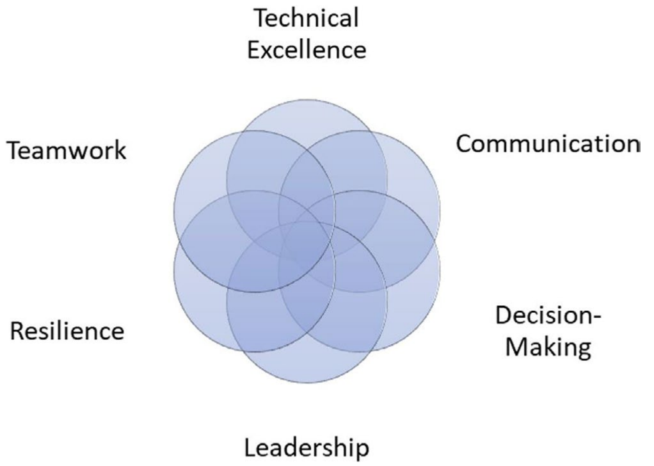

FIGURE 1 Conceptual model of professional flight competencies. This illustrates the overlap and interaction of each competency

4.1 | Technical excellence

The National Aeronautics and Space Administration (NASA) published a paper titled *Technical Excellence: A requirement for good engineering* by Gill and Vaughn. The authors explained that workers need to be creative, skilled, problem solving, critical thinkers while having leadership qualities (Gill & Vaughn, 2007). Furthermore, Gill and Vaughn (2007) posited that all organizations should strive for technical excellence. Technical excellence from NASA's organizational point of view has four guiding principles:

1. Clearly documented policies and procedures.
2. Effective training and development.
3. Engineering excellence; and
4. Continuous communications.

To adjust NASA's framework for the professional flight program, in accordance with the mission and vision, the following attributes of technical excellence are proposed:

1. Promotion of excellence beyond compliance with FAA and academic accreditation standards.
2. Innovation in curriculum development, delivery, and assessment; and
3. Data-driven continuous improvement efforts.

ICAO (2018) provides the global civil aviation community with Standards and Recommended Practices (SARPs). SARPs are set forth to assist ICAO member States in managing safety risks and to harmonize global aviation operations and efficiency. ICAO Annex 1 (2016b) provides SARPs for Personnel Licensing including pilot certificates. For instance, Commercial Pilot applicants are to have *knowledge* in at least the following areas: air law, aircraft knowledge for airplanes, aircraft performance, human performance, meteorology, navigation, operational procedures, principles of flight, and radiotelephony. The applicant must demonstrate the *skill* to perform as the pilot-in-command of an aircraft within the appropriate category of aircraft, the procedures and maneuvers with a degree of competency appropriate to the privileges granted to the holder of a commercial pilot certificates, and to:

1. Recognize and manage threats and errors.
2. Operate the aircraft within its limitations.

3. Complete all maneuvers with smoothness and accuracy.
4. Exercise good judgment and airmanship.
5. Apply aeronautical knowledge; and
6. Maintain control of the aircraft at all times in a manner such that the successful outcome of a procedure or maneuver is assured (p. 2–15).

In addition to the demonstration of knowledge and skills, pilots must have successfully *experienced* at least the minimum flight hours outlined in ICAO Annex 1 (ICAO, 2016b). Proficiency within the behavioral markers for each skill requirement must be achieved. While ICAO provides international guidance, the Federal Aviation Administration is responsible for complying with SARPs and oversees the issuance of certificates and ratings in the United States (FAA, 2007). Airmen Certification Standards (ACS) drive the specific definitions of knowledge, skills, and abilities or flight experience to produce the product, in this case, a professional pilot (FAA, 2018). The ACS offers a comprehensive description of the standards that a certificate applicant needs to demonstrate in order to pass both the knowledge and practical tests for a certificate or rating. The ACS guidance connects specific, appropriate knowledge, and risk management elements to specific skills. Additionally, the ACS enhances safety by using the risk management section in each area of operation to translate special emphasis items and abstract terms like "aeronautical decision-making" into specific behaviors relevant to each task (FAA, 2018). In addition to the ICAO SARPs and FAA mandated standards, the professional flight program degree program at Purdue University is accredited by the Aviation Accreditation Board International (AABI). AABI (2017) states:

> Accreditation is a system for recognizing educational institutions and/or their professional programs that achieve and maintain a level of performance, integrity and quality that entitles them to the confidence of the educational community, the industry and the public they serve.
>
> (p. 1)

To meet the standards of the accreditation body, certain criteria must be met, reviewed periodically, and proven through evidence (AABI, 2017). Referring to the literature, a technically excellent organization should strive to excel beyond regulatory and academic accreditation standards. At the minimum, pilots seeking flight credentials must be assessed from the airman certification standards (ACS) and AABI accreditation standards. However, in order to truly develop graduates with technical excellence, they must undergo a more robust assessment of knowledge, skills, and abilities—mapped against internationally acclaimed standards. These standards will be based on an industry-accepted quality-assurance model like the Advanced Qualification Program (AQP). According to the FAA (2016b), AQP is founded on the principle that the content of training and checking activities should be directly driven by the operational conditions. The first step in AQP, therefore, is the development of specific task analysis, which begins with the completion of a comprehensive task listing for flight crewmembers. The task listing should cover normal, abnormal, and emergencies to which the pilot may encounter within the realm of operations (FAA, 2016b). This model will yield a comprehensive model of Technical Excellence at the three levels of proficiency (emerging, developing, and proficient) across psychomotor, cognitive, affective, and/or interpersonal aspects.

Innovation in curriculum development is more than keeping the curriculum consistent with the extant industry needs. It is about positioning the professional flight degree program at a strategic advantage against its competitors and consistently producing globally competitive graduates. Thus, innovation will necessarily address the grand challenge of producing highest-quality professional pilots at the fastest rate and least total cost. The faculty will strive to find creative ways of developing sophisticated technical knowledge and skills using the latest technology, appropriate matching of learning and teaching styles, efficient use of class/lab time, and industry alliances that minimize capital costs for the program.

According to Ericsson, Hoffman, Kozbelt, and Williams (2018), applying knowledge, skills, and abilities is not enough to achieve mastery. It is the inclusion of excellence as a way of being that facilitates the pathway to mastery. Through the integration of excellence as part of the culture, proper academic teaching, assessments, and compliance with technical standards, the professional flight program can produce high-quality graduates prepared to enter the workforce. It is important to note that being proficient in FAA terms does not necessarily achieve proficiency from an academic perspective. For example, a "C" letter grade may be considered sufficient to meet FAA's proficiency requirement; however, academic standards may expect an "A" grade as an indicator of academic proficiency. Therefore, the Airmen Certification Standards (ACS) will be considered the minimum standards in the professional flight program—thus, they will form "Level 1" achievement or "Emerging" level of proficiency. Such a designation sets the stage for students to achieve subsequent "badges" or additive credentials which indicate proficiency at higher levels. The professional flight students at will be required to exhibit technical excellence. Technical excellence was divided into two sub-competencies:

1. Airmanship—demonstrates the minimum Airmen Certification Standards. Operate safely and effectively in the national airspace system while integrating leadership, communication, teamwork, resilience, and decision-making.
2. Integrate certification standards with academic standards and competencies.

4.2 | Communication

Communication can be classified into three modes: verbal, nonverbal, and visual (Gudykunst, 2003). Verbal communication is split in two sub-categories: written and oral communication. Written communications can range from official organizational memos to electronic messages. The effectiveness of oral communication depends on the clarity, voice inflection, tone, volume, speed, and even concurrent nonverbal communication such as body language and visual cues (Plasek et al., 2011). Nonverbal communication entails communicating by sending and receiving wordless messages (Ben-Nun, 2014). The third mode of communication is visual and can be accomplished through visual aids such as displays, electronic presentations, drawings, schematics, graphs, and charts (Griffin, 2006).

Modes of communication are irrelevant without proper context. Communication can be placed into five primary contexts: psychological, relational, situational, environmental, and cultural (Desai, 2010). The various contexts are found throughout flight and organizational operations. Communication is a vital competency for pilots to operate safely, effectively, and efficiently in a commercial air transport environment (Department of Transportation, 2018). Effective communication is necessary in-flight operations and utilizes different modes and contexts. ICAO guidance includes the three primary categories of communication and contextual elements. The ICAO Manual 9995 (2013) indicates pilots should be able to demonstrate effective oral, nonverbal and written communication, in normal and nonnormal situations. ICAO (2013) provides nine behavioral indicators:

1. Ensures the recipient is ready and able to receive the information.
2. Selects appropriately what, when, how, and with whom to communicate.
3. Conveys messages clearly, accurately, and concisely.
4. Confirms that the recipient correctly understands important information.
5. Listens actively and demonstrates understanding when receiving information.
6. Asks relevant and effective questions.
7. Adheres to standard radiotelephone phraseology and procedures.
8. Accurately reads and interprets required company and flight documentation.
9. Accurately reads, interprets, constructs, and responds to datalink messages in English (p.73).

The behavior indicators identified by the citations produced the following four targets for graduates of the professional flight program:

1. Be able to understand the different modes and contexts when communicating.
2. Create messages appropriate to the context, audience, and purpose.
3. Critically analyze messages; and
4. Articulate communicative goals (self-efficacy).

Guidance from the communication literature resulted in the following sub-level competencies for the professional flight program:

1. Students are able to understand the different modes and contexts when communicating.
2. Students are able create messages appropriate to the context, audience, and purpose.
3. Students are able to critically analyze messages.

4.3 | Leadership

Leadership is a "set of traits, qualities and behaviors possessed by the leader that encourage the participation, development, and commitment of others within the organization" (Bolden & Gosling, 2006, p. 155). A study by Munford, Campion, and Morgeson (2007) conceptualized the leadership skill requirements in four different categories: cognitive, interpersonal, business, and strategic. Cognitive skills are vital for most activities in which leaders are engaged. The cognitive skill requirements include the ability to learn and adapt, critical thinking, and effective communication. The interpersonal skill requirements involve intercultural, social, and interpersonal skills necessary to interact with and influence others. Business skills involve the effective management of human and financial resources, as well as operational analysis. Strategic skill requirements are paramount for leaders to identify and solve problems while assessing the downstream consequences of such processes. Even though the four leadership categories are empirically distinguishable, and cognitive skill is the backbone of the leadership skills, all are needed and have implications for individual, team, and organizational performance. These leadership skills should translate into behavioral competencies that will allow leaders to adapt and better respond to the needs and expectations of their jobs (Cumberland, Herd, Alagaraja, & Kerrick, 2016).

Leadership is a vital competency for pilots to operate safely, effectively, and efficiently in a commercial air transport environment (Kanki, Helmreich, Anca, & Anca, 2010). Being pilot-in-command of an aircraft is all about leadership, and it embodies a host of skills, knowledge, and abilities. Leadership is not simply having responsibility for the outcome of the flight, but for taking the authority to make the difficult and final decisions, and when the situation requires, making a command decision (IATA, 2013; ICAO, 2013). These concepts and processes are central to the mission of the professional flight program, and they are promoted within the curriculum.

Various professional disciplines (American College of Cardiology, 2018; National Education Association, 2018; U.S. Coast Guard, 2018) have harmonized leadership science with the professional expectations of their respective field and identified several behaviors of the leadership competency. The following five behavior indicators are relevant to graduates from the professional flight program:

1. Values, inspires, and fosters team commitment to accomplish group and organizational goals.
2. Creates an environment of open communications.
3. Makes well-informed and effective decisions even when navigating in an environment of ambiguity and uncertainty.

4. Demonstrates the ability to manage and resolve conflicts in a constructive manner.
5. Uses critical-thinking processes to analyze the strengths and weaknesses of various approaches to the work.

Leadership in aviation is both a science and an art, and it is a critical competency to operate in a highly complex system (Cortes, 2008). In the cockpit, for example, a leader becomes a means for change and influence, which often impacts aviation efficiency and safety (ICAO, 1989). Flight crew members need to demonstrate multiple aspects of leadership in the operational environment. IATA (2013) and ICAO (2013) have identified the following 13 leadership behavior indicators:

1. Understands and agrees with the crew's roles and objectives.
2. Creates an atmosphere of open communication and encourages team participation.
3. Uses initiative and gives directions when required.
4. Admits mistakes and takes responsibility.
5. Anticipates and responds appropriately to other crew members' needs.
6. Carries out instructions when directed.
7. Communicates relevant concerns and intentions.
8. Gives and receives feedback constructively.
9. Confidently intervenes when important for safety.
10. Demonstrates empathy and shows respect and tolerance for other people.
11. Engages others in planning and allocates activities fairly and appropriately according to abilities.
12. Addresses and resolves conflicts and disagreements in a constructive manner.
13. Projects self-control in all situations.

A cross-disciplinary integration between the leadership behavior indicators identified by the professional disciplines previously cited, and ICAO (2013) and IATA (2013), provides the following common performance themes most salient to the outcome targets for the graduates from the professional flight program:

1. Demonstrates the knowledge, skills, and abilities to manage, lead, and empower others to efficiently address organizational and group needs and objectives.
2. Creates an atmosphere of open communication and encourages team participation.
3. Makes well-informed and effective decisions even when navigating in an environment of ambiguity and uncertainty.
4. Demonstrates strong ethics and provides a sense of safety.

Guidance from the leadership literature resulted in the following sub-level competencies for the professional flight program:

1. Demonstrates the knowledge, skills, and abilities to manage, lead, and empower others to efficiently address organizational and group needs and objectives.
2. Manages and resolves conflicts and disagreements in a constructive manner.

4.4 | Decision-making

Scholars indicate there are two broad categories of decision-making theory: normative and descriptive (Hansson, 1994). Normative decision-making theory is one that describes how decisions ought to be accomplished. In contrast, descriptive decision-making theory pertains to how the decision was *actually* accomplished, in a post hoc fashion. Theories have led to the development of a range of training and practices to improve the decision-making process. Many of these use the "classical decision method" within the normative category which involves the rational analysis of options in order to make the best choice. In simple terms, this method of decision-making can be described as a step-by-step process which comes in different variations. One example is identifying the problem, gathering information, identifying alternatives, weighing the evidence, choosing, acting, and reviewing the results (Royal Institute of Technology, 1994). Proactive and effective decision-making can provide a competitive edge to organizations, reduce risks and liability, and improve critical thinking and situational awareness (Concordia, 2017). Variations of step-by-step decision-making processes can be taught, evaluated, and utilized in discipline-specific contexts. The FAA (2016a) defines Aeronautical Decision Making (ADM) as "a systematic approach to the mental process used by pilots to consistently determine the best course of action in response to a given set of circumstances. It is what a pilot intends to do based on the latest available information" (p. 2–2).

Previously, researchers believed that good ADM was an outcome of learning largely associated with field experience (FAA, 2016b). However, more recent findings indicate that ADM could be taught and is not as dependent on first-hand experience (FAA, 2016b). Therefore, the FAA mandated ADM as part of the flight training curriculum. The FAA (2016a) pinpoints six steps for good decision-making:

1. Identify personal attitudes hazardous to safe flight.
2. Learn behavior modification techniques.
3. Learn how to recognize and cope with stress.
4. Develop risk assessment skills.
5. Use all available resources.
6. Evaluate the effectiveness of one's ADM skills.

Based on the previous literature, decision-making can be initially taught as a step-by-step process for varying contexts. As students become more experienced, they will be able to consciously adjust their process. For example, in time critical situations decision-making process follows a Recognition Primed Decision Model (RPD) (Kline, 2008). This model combines instinct, intuition, and systematic methods, thus explaining how people can make good decisions when a plan has yet to be developed or under time pressure. The RPD model details how people use their previous experience or heuristics. Patterns highlight important cognitive cues, provide expectancies, recognize desired goals, and suggest typical types of reactions. If expectations are violated, a person must reassess the situation and seek more information. After reassessing the situation and determining a form of action that will work, one can execute the action (Kline, 2008). Behavioral markers are also guided by ICAO (2013) standards. Pilots must seek adequate information from appropriate sources and understand why things have gone, or could go, wrong. Additionally, they must demonstrate the following behaviors:

1. Employ proper problem-solving strategies.
2. Persevere in working through problems without reducing safety.
3. Apply appropriate and timely decision-making processes; and
4. Set priorities appropriately and consider options effectively.

To assist students in becoming competent in decision-making inside the flight deck and classroom, the above behavioral markers were reconfigured in the form of student learning outcomes as follows:

1. Articulate the impact of their own decision-making abilities.
2. Apply appropriate decision-making process.
3. Accurately identifies necessary information.
4. Evaluate outcomes effectively; and
5. Demonstrate the ability to address complex issues.

Guidance from the decision-making literature resulted in the following sub-level competencies for the professional flight program:

1. Applies appropriate decision-making processes.
2. Demonstrates the ability to address complex issues.

4.5 | Resilience

Resilience is defined as "one's ability to adapt effectively in the face of severe adversity in which it allows for the restoration of equilibrium" (Cooke, Cooper, Bartram, Wang, & Mei, 2016, p. 2). Highly complex organizations need resilient professionals due to the ever-growing global competition, turbulent business environments, organizational restructuring, and technological innovation. Professionals should have the competence to "face unprecedented changes, and adapt successfully to challenging roles, tasks, and situations" (Malik & Garg, 2018, p. 77). Empirical evidence indicates that resilience could elicit positive individual and organizational outcomes such as higher job satisfaction, enhanced levels of employee engagement, and increased productivity (Rankin, Lundberg, Woltjer, Rollenhagen, & Hollnagel, 2014). This is because resilient professionals view stress and change as opportunities and/or challenges, display an action-oriented approach, demonstrate a tolerance to unexpected outcomes, and can effectively adapt to changes (Connor & Davidson, 2003). In addition, they prefer to take the lead in problem solving, are capable of effective adaptations and coping successfully in response to failures, and they think of themselves as strong people (Cooke et al., 2016). Other behavioral indicators of resilience include the willingness to ask others for support when dealing with difficult situations, and commitment to life and professional goals (Nemeth & Olivier, 2017).

Resilience is a vital competence to operate in a dynamic, complex, and ambiguous sociotechnical system, like commercial aviation (Dekker & Lundström, 2007). Flight crews are trained to follow procedures in order to reduce risks. However, they are often required to recognize, adapt, and tolerate to confront uncertainty within the workplace (Lely, 2009). Resilience is especially required when pilots face emergency situations. Previous aircraft accidents and incidents (Brazilian Aeronautical Accidents Investigation & Prevention Center, 2013; NTSB, 1990) indicate that flight crews must be flexible and adaptable, think outside the box, and to communicate effectively in order to cope with situations well beyond their individual expertise (Lely, 2009). According to IATA (2013), resilience is a competence that engenders confidence and enables pilots to deal competently with challenges encountered in flight operations, particularly when threats are unknown. When preparing the next generation of aviation professionals, it is important to consider that aviation is an inherently and permanently imperfect system. Therefore, flight crews should have the competence to effectively address problems that are beyond the minimum flight and academic standards. These concepts and processes are central to the mission of Purdue University's Professional Flight Program, as well as promoted within the curriculum.

Resilience is a competence that could be taught and practiced (Carpio, Castro, Huerto, Highfield, & Mendelson, 2018). To be successful in today's flight training environment, students need to develop resilience to effectively recognize, absorb, adjust or adapt, and tackle threats that fall outside the aviation system design base. The student learning outcomes for graduates of the professional flight program are as follows:

1. Demonstrates the knowledge, skills, and abilities to focus and think clearly while under pressure.
2. Uses an objective approach to problem-solving.
3. Displays effective communication skills and the ability to seek out support in order to achieve positive outcomes.
4. Demonstrates confidence in their ability to address problems and obstacles that they encounter.
5. Displays an action-oriented approach; and
6. Views difficulties and failures as challenges and opportunities to learn and develop.

Guidance from the communication literature resulted in the following sub-level competencies for the professional flight program:

1. Demonstrates the knowledge, skills, and abilities to focus and think clearly while under pressure.

2. Uses an action-oriented approach and objective approach to problem-solving.

Graduates of the professional flight program will integrate and display the resilience skills that will enable them to adapt to changing circumstances; perceive failures and challenges as opportunities to learn and develop; apply their problem-solving abilities using an action-oriented approach; display a commitment to communicating and accepting fresh perspectives on a problem; and display the resilience competence that is in harmony with their technical skills, level of authority, and responsibility.

4.6 | Teamwork

Salas, Rosen, Burke, and Goodwin (2009) defined teamwork as "a set of interrelated thoughts, actions, and feelings of each team member that are needed to function as a team, and that combine to facilitate coordinated, adaptive performance and task objectives resulting in value-added outcomes" (p. 43). Previous definitions of teamwork (Dyer, 1984; Hackman, 1987; Salas et al., 2009; Salas, Stagl, Burke, & Goodwin, 2007; Sundstrom, de Meuse, & Futrell, 1990) have some common fundamentals, such as interdependency and shared responsibility among team members while working toward common goals. Empirical evidence indicates that working in teams improves individual satisfaction, effort, and performance (Wagner, 1995). According to Driskell and Salas (1992), goal setting, task involvement, and information sharing are teamwork characteristics that lead to enhanced team performance.

Teams can provide a wider variety and amount of skills and knowledge on which to draw, and offer comprehensive, creative, and innovative solutions to unknown and/or complex problems. Previous research has identified the following core skills and abilities of teamwork: closed-loop communication (Salas, Sims, & Burke, 2005); team leadership (Salas et al., 2009); flexibility (Salas et al., 2009); and resilience (Orasanu, 2010). Teamwork orientation, the individual's propensity to work interdependently in a team, is another behavior indicator of the teamwork competence. Teamwork orientation increases personal satisfaction and performance (Mustafa, Glavee-Geo, & Rice, 2017), and the willingness to exchange information and cooperate with team tasks (Costa, Passos, & Bakker, 2014), which results in a constant positive learning experience (Salas et al., 2009).

High-reliability industries are increasingly turning to team-based structures to contend with an ever-changing and complex environment (Leonard, Graham, & Bonacum, 2004). Work teams are recommended when professionals have specialized skills, responsibilities, and roles. Most importantly, when those professionals work in a high-technology environment, perform interdependent and well-coordinated tasks that require effective communication and a shared mental model, and when these professionals must undergo thorough initial and recurrent training to perform their jobs (Brannick, Prince, & Salas, 2005). In effective teams, members maintain an awareness and monitor fellow members' work to prevent mistakes and especially to ensure they will meet or exceed their organization's expectations (Salas et al., 2005). Nevertheless, effective teams could offer greater flexibility, resilience, productivity, and creativity than any one individual can offer.

Another perspective on teamwork is the impact of globalization. Overall, globalization has brought cross-cultural considerations to aviation teams. Thus, culturally diverse teams must demonstrate intercultural abilities to meet or surpass the organization's goals. Previous research studies suggest that the basic characteristics of successful multicultural teams are not much different from relatively homogenous teams: clarity of team goals; complementary knowledge, skills and experience of team members; clear responsibilities of team roles; high degree of commitment; cooperative team climate; and increased team effectiveness (Miliken & Martins, 1996). However, in addition to the above characteristics, multicultural teams need to develop a larger number of alternatives and better ideas; demonstrate the capability to adapt more quickly to changing environmental conditions; bring creativity and innovative mindset; and be capable of rendering decisions more effectively than homogenous teams (Matveev & Nelson, 2004).

The global air transportation industry will need 42,000 new aircraft until 2037 (Boeing, 2018). Moreover, approximately 800,000 new pilots, 754,000 new maintenance technicians, and 890,000 new cabin crew will be needed to fly and maintain the worldwide aircraft fleet over the next two decades. Emerging and developing economies in Latin America, Asia, Africa, and in the Middle East, as well as strong aviation markets in the United States and Europe, will create challenges and opportunities across cultural and national boundaries for both aviation stakeholders and professionals in the next 20 years (IATA, 2018). Thus, the knowledge, skills, and abilities to work effectively in multicultural teams will become a vital competence for aviation professionals (Lustig, 2005).

When preparing the next generation of aviation professionals, it is important to consider that teamwork provides a redundant system that could have a positive impact on individual and team performance as well as aviation safety and efficiency, critical factors to the aviation industry. Therefore, flight crews should have the competence to work as members of a team to effectively convert team inputs into targeted outcomes. These concepts and processes are central to the mission of the flight program, and they are promoted within the curriculum.

Teamwork is a competence that should be taught and practiced (Brannick et al., 2005). To be successful in today's professional flight environment, students need to develop knowledge, skills, and abilities to work interdependently, adaptively, cooperatively, and dynamically toward shared and valued goals. In addition, they should develop the knowledge, skills, and abilities to guide, coordinate, and facilitate teamwork activities across cultural boundaries and as the team leader. The student learning outcomes for graduates of the professional flight program are as follows:

1. Displays a teamwork orientation.
2. Demonstrates the knowledge, skills, and abilities to enable effective teamwork and interdependent action by team members.
3. Recognizes deviations from expected action and displays the flexibility to readjust actions accordingly while working as a member of a team.
4. Displays effective communication skills, and the ability to seek out from and to provide support to team members in order to enhance team performance.
5. Demonstrates the ability to assign tasks, direct and coordinate the activities of other team members, assess team performance, and facilitate team problem solving in order to achieve the expected goals; and
6. Demonstrates the ability and skills to work in multicultural teams.

Guidance from the communication literature resulted in the following sub-level competencies for the professional flight program:

1. Demonstrates the knowledge, skills, and abilities to enable effective teamwork and interdependent action by team members.
2. Manages and resolves conflicts and disagreements in a constructive manner.

4.7 | Future steps

The organization of the proficiency-level descriptors represents professional flight skills development across a continuous spectrum of increasing proficiency, starting with basic competencies professional flight students possess when they enter the program, and concluding with the lifelong learning in which all aviation professionals engage. The three levels represent three stages of development, describing expectations for knowledge and skills at each level as the breadth of capabilities expands and concepts transition from ideas to practice.

The foundation of the assessment of the competencies will be the Bloom's Taxonomy to include psychomotor, cognitive, affective, and interpersonal levels (Anderson & Krathwohl, 2001; Bloom & Krathwohl, 1956; Callister, 2010; Ebert & Fox, 2014; ICAO, 2016a). The Bloom's taxonomy will be used to describe instructional objectives in the professional flight program educational documents, conduct objectives-based assessments on the professional flight program students' achievement, "and for aligning curriculum and assessment" (Lee, Kim, Jin, Yoon, & Matsubara, 2017, p. 11).

The three suggested proficiency-level descriptors for the professional flight program are as follows:

> Level 1—Emerging: Students within this category demonstrate Airmen Certification Standards for the appropriate certificates and ratings, generally make rapid progress, learning basic and some advanced aviation knowledge and skills for immediate needs, as well as beginning to employ appropriate academic and discipline specific characteristics.
>
> Level 2—Developing: Students within this category are challenged to reflect upon strengths and weaknesses pertaining to the Airmen Certification Standards, increase their aviation knowledge and skills in an increasingly greater number of situations, and learn a wider variety of professional attributes.
>
> Level 3—Proficient: Students within this category show appropriate knowledge, skills and abilities for operating transport category aircraft, exhibit life-long learning habits, and demonstrate the ability to conduct themselves in accordance with discipline professional standards.

As the development of the hybrid competency-based education model to be employed in the program progresses, program faculty will develop the related student learning outcomes based on the competencies presented, using the suggested proficiency-level descriptors to delineate the outcomes into measurable categories. Associated competencies will then be measured for the three levels (developing, emerging, and proficient) of student achievement.

Each competency will need to be mapped to the proper course for evaluation. Formative and summative assessments must be developed along with appropriated rubrics. Testing and research processes will have to be conducted to ensure reliability and validity. Additionally, a robust data management plan will have to be developed for continuous improvement efforts.

The development of competencies based on empirical data will provide the faculty another means of assessment within the classroom and flight courses. These data will allow for more precision in understanding student progress as well as the program overall. Furthermore, in the future, there may be opportunities for the development of a true competency-based education program in aviation. The processes explained in this study to determine and assess the professional flight program competencies, as well as the correspondent student learning outcomes using the proficiency-level descriptors will lead to a more comprehensive and consistent learning process across the courses that comprise the professional flight program curriculum (Mott et al., 2019).

5 | CONCLUSION

In 2018, with support from the institution, faculty members within the professional flight program initiated development of competencies. It is anticipated that these competencies will improve the quality of learning, prepare students for the workforce, and increase assessment processes as well as continuous improvement efforts. It may also be possible that future research may provide evidence that competencies improve safety indicators. The next step in the development of the hybrid competency-based education model is to map the competencies to the appropriate courses, develop detailed rubrics, and test formative as well as summative assessments. Results of these efforts will allow the program leadership to refine elements in the curriculum.

CONFLICT OF INTEREST STATEMENT

No conflicts declared.

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Brian Dillman has been an Associate Professor of Aviation and Transportation Technology at Purdue University since July 2007. Professor Dillman holds Airline Transport Pilot certification as well as Certified Flight Instructor for Airplane, Instrument, and Multi-Engine. He is a Designated Pilot Examiner with Private, Commercial, Instrument, Multi-Engine, Flight Instructor, and Sport Pilot designations. He has extensive experience is developing methods, implementing programs, and evaluating systems within all areas of aviation.

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