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Development of digital competency curriculum framework for prospective ground handling professionals

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ABSTRACT

The rise of IT technology in airports has highlighted the need for personnel equipped with digital skills to manage modern aviation operations effectively. This study investigates whether the current workforce possesses adequate IT competencies by conducting field observations at Yogyakarta International Airport (YIA) and interviews with its staff and general manager. The findings emphasize the pivotal role of IT skills in enhancing safety, streamlining operations, and delivering superior service quality. However, significant barriers, such as limited resources, resistance to change, and the absence of standardized frameworks, hinder the development of these competencies. The study proposes tailored training programs that integrate IT skill development into routine staff training and emphasizes the creation of a structured digital competency curriculum framework for ground-handling professionals. These results underscore the urgent need for digital competency development in the aviation sector, aligning with global trends that prioritize IT in improving reliability and safety standards. Addressing these gaps is imperative for fostering a resilient and adaptable workforce capable of meeting the industry's evolving technological demands.

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1. INTRODUCTION

Ground handling workers are at the forefront of airport operations; they are responsible for a broad spectrum of tasks including aircraft towing, baggage handling, cargo loading, and interfacing with customers. These roles are critical in ensuring that all facets of airport logistics work in tandem to maintain operational fluidity. In the digital age, the skill set required for these roles has evolved considerably. No longer can ground handling personnel rely solely on procedural know-how and manual dexterity; rather, they must integrate a range of digital competencies into their everyday practices to keep pace with emerging technological demands (Ala-mutka, 2020).

In modern airports, automated tracking systems and cloud-based management tools have become indispensable. Such systems facilitate real-time monitoring of assets and enable rapid communication across different departments. For example, automated

baggage tracking systems not only help reduce instances of mishandled luggage but also ensure that any deviation from the expected process is flagged immediately (Charernnit, 2023; IATA, 2022). Cloud-based management tools further aid in the dynamic allocation of resources through real-time scheduling, thereby reducing turnaround times and mitigating the risk of delays (Kabashkin et al., 2023). Ground handling workers who are adept in using these digital platforms are better positioned to troubleshoot routine technical issues, significantly reducing the margin for error that might otherwise lead to cascading operational delays.

Effective communication is a cornerstone of safe ground handling operations. Digital communication platforms—such as mobile apps and instant messaging systems—enable rapid dissemination of critical information, from safety alerts to operational adjustments. When ground handling personnel possess the necessary digital skills, they can navigate these platforms with ease and contribute to enhanced situational awareness (ICAO, 2019). Conversely, inadequate digital skills may result in miscommunication or delayed responses, which heighten the risk of safety protocol violations and compromise operational integrity. A breakdown in communication, even if it starts with a simple technical glitch, can trigger a cascade of issues across the tightly interlinked processes of an airport (Redecker, 2017).

Digital transformation not only enhances operational mechanics but also significantly improves workforce engagement and overall airport efficiency. Digital training empowers employees, broadens their skill sets, and increases motivation, leading to fewer errors and fostering a culture of continuous improvement. When ground handling workers effectively utilize integrated digital tools, benefits extend across the entire airport ecosystem, from safety enhancements to improved customer service. Case studies show that airports embracing digital solutions experience fewer delays, reduced errors, and greater efficiency, whereas a lack of digital proficiency hinders operational effectiveness. These findings highlight the urgent need for training programs that prioritize digital competency as a key component of vocational education in aviation (Poulaki et al., 2021; UNICEF, 2022).

Additionally, as airports increasingly position themselves as technologically advanced and competitive entities in a global market, having a digitally skilled workforce becomes a strategic differentiator (Bitegeko et al., 2024). Ground handling workers who can harness digital solutions are instrumental in driving operational excellence and ensuring that the airport remains responsive to the rapidly evolving demands of the aviation industry (Voogt et al., 2013).

Digital transformation plays a vital role in addressing these challenges. Several airports, such as Changi Singapore, JFK New York, and iGA Istanbul, are already leveraging virtual reality (VR) and augmented reality (AR) to enhance the passenger experience through virtual tours and entertainment options. The modern traveler, who relies on digital devices, expects an efficient and personalized journey with self-service options, mobile capabilities, and real-time updates (Julie Aarthy et al., 2021).

As digital technology advances, the role of officers in the aviation industry will only increase. Innovations such as artificial intelligence (AI) and machine learning promise to optimize operations by automating complex tasks, predicting maintenance needs, and personalizing customer experiences. Embracing these advancements will be key for aviation stakeholders to remain competitive in an increasingly digitalized global market, ensuring continued growth, resilience, and sustainability in the years to come (Kashyap, 2019; Rikala et al., 2024).

The digital competencies essential for aviation personnel are being substantially transformed by the incorporation of blockchain, artificial intelligence (AI), and the Internet of Things (IoT) into airport operations. These technologies improve data management, security, and efficiency, necessitating that employees acquire new skills

that exceed their conventional operational knowledge (Kabashkin et al., 2023; Kabashkin & Shoshin, 2024)

The Internet of Things (IoT) facilitates the real-time monitoring of aircraft maintenance, passenger traffic, and baggage management, necessitating that aviation personnel develop the capacity to interpret sensor data and optimize processes. The workforce must be able to acclimate to AI-driven decision-making and machine learning applications, as AI enhances predictive maintenance, customer service automation, and security screening.. Blockchain technology improves the security of ticketing, identity verification, and supply chain transparency, thereby encouraging employees to develop a high level of proficiency in cybersecurity and smart contracts (Kabashkin et al., 2025; Merlo, 2024).

In order to maintain their effectiveness, aviation professionals must foster data analytics, cybersecurity awareness, and AI collaboration as terminals continue to implement digital tools. In an industry that is characterized by automation and connectivity, traditional skill sets are no longer adequate, necessitating the development of adaptability and continuous learning. In order to guarantee that employees are capable of navigating the constantly changing technological environment, airports and airlines must allocate resources to training programs (Filinovych & Hu, 2021).

With the rapid development of technology in aviation, qualified human resources are needed to operate, maintain, and repair these digital facilities (Abu et al., 2025). All education industries, especially aviation education, must be able to adapt to this situation. Some aviation education not only teaches about mandatory but also includes lessons related to information technology, data analysis, big data, and artificial intelligence.

The literature on digital competency and vocational training is vast and continually evolving. At its core, digital competency encompasses a range of knowledge, skills, and attitudes required to participate effectively in today's digital society (Ferrari et al., 2012; Voogt et al., 2013). As information and communication technologies have become more pervasive, these competencies have expanded beyond basic computer literacy, including complex problem-solving, critical thinking in technical environments, and ethical use of digital resources. In vocational education, specifically aviation and airport operations, there is an emerging consensus that traditional training methods must be revisited and revised. Digital competencies must be aligned with the practical demands of a rapidly modernizing industry where safety, efficiency, and precision are paramount (Mendonca et al., 2019; Redecker, 2017).

Several key frameworks and models have informed our understanding of digital literacy and competency over the past decade. One seminal contribution is the European Digital Competence Framework for Citizens (DigComp 2.0), which systematically categorizes digital skills into core areas such as information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving (Dou, 2020; Ferrari et al., 2012). This taxonomy provides a comprehensive overview of what constitutes digital literacy and offers a scalable model for integration into various education and training contexts.

Building on this, (Redecker, 2017) has emphasized the dynamic interplay between digital skills and learning outcomes. He argues that competencies must be contextualized to suit specific professional domains, ensuring that theoretical knowledge is tightly coupled with practical applications. For instance, while a generic digital literacy course might cover operating computer systems or using office productivity tools, ground-handling workers need to extend these skills to specialized applications such as real-time data monitoring, automated logistics software, and cybersecurity practices tailored to the high-security environment of airports (Redecker, 2017; Voogt et al., 2013).

Competency-based education (CBE) has become a key approach in vocational training, focusing on measurable outcomes and performance-based assessments rather

than traditional content delivery. This model is particularly effective in aviation, where reliability and safety are paramount, and has been widely used in pilot and cabin crew education. However, ground-handling personnel have not yet fully benefited from CBE, as conventional training methods fail to address the complexity of their roles. With the increasing use of integrated digital platforms in automation and real-time management, ground-handling workers require a curriculum that combines technical skills like data analytics and troubleshooting with interpersonal skills for collaboration in a digitalized environment. Developing a competency-based framework tailored for ground handling is essential to ensure professionals can adapt to evolving technological demands (Dinçer, 2023; Gonzalo, 2024; Kabashkin et al., 2023; Suyatmo et al., 2024).

The rapid digitization of aviation operations has been thoroughly documented in academic and industry-focused literature. Early research (Frick & Thomas, 2014) chronicled the initial waves of digital implementation, such as automated check-in systems and digital flight information displays, which revolutionized passenger processing. More recent studies highlight an evolution that now includes the integration of the Internet of Things (IoT), artificial intelligence (AI), and blockchain technology into the management of ground-handling functions. These technological adoptions have fundamentally redefined roles and responsibilities within airport operations (Moghadasnian, 2025; Sun et al., 2020).

For example, the automation of baggage handling systems and the deployment of real-time scheduling platforms necessitate a workforce that is not only familiar with the operational aspects of these technologies but also proficient in troubleshooting and system optimization(Shekhar, 2025). Such advancements illustrate the critical intersection where traditional operational knowledge must meet modern digital proficiency—a juncture at which a specialized digital competency curriculum becomes indispensable (Ates & Durmaz, 2022; Gonzalo, 2024).

According to (Prayogi, 2020), digital competence includes the ability to create digital learning content or media, communicate using technology and digital media, protect against the impact of learning content or media, solve problems related to technology-based learning, and create information. Ultimately, instructors and students can make the most of the available technology while understanding the advantages and disadvantages of technology-based or digital learning (Ramoso & Ortega-Dela Cruz, 2025).

The persistent gap between theoretical digital literacy and its practical application in vocational settings is a recurring theme in the literature. (Chalale et al., 2025; Ferrari et al., 2012; Moin et al., 2025; Nalaka et al., 2025) demonstrated that while educators and trainers often have a firm grasp of digital principles in theory, there remains a noticeable disconnect in applying these tools in real-world environments. This discrepancy is exacerbated in high-stakes settings like ground handling, where the cost of misapplication can be severe, affecting safety and operational continuity.

With their unique logistical challenges and stringent safety requirements, ground handling operations exemplify the need to convert abstract digital theories into concrete, actionable skills. Research by (Gaviria et al., 2024; Updegrove & Jafer, 2017) has underscored the importance of simulation-based training and scenario planning to bridge this divide. Dynamic feedback systems, role-playing exercises, and the integration of digital simulations in training modules are recommended pedagogical approaches that have influenced the design of modern curriculum frameworks aimed at equipping trainees with practical digital competencies.

Research consistently highlights the strong link between digital proficiency and improved operational outcomes. Organizations with a digitally skilled workforce achieve higher performance levels, experience fewer errors, and adapt more effectively to technological changes. In airport operations, even small advancements in digital skills can significantly enhance safety measures and overall efficiency. Additionally, integrating

digital competencies into vocational training improves technical expertise and fosters continuous learning and innovation. Given the rapid pace of technological advancements in aviation, adaptability and digital literacy are crucial for maintaining operational resilience, ensuring that airports uphold high safety standards while responding to emerging digital challenges (Witt, 2023).

Despite the growing number of digital competency frameworks, research on vocational training models for ground handling remains scarce. While IATA has developed guidelines for best practices in ground operations, these are rarely integrated with broader digital literacy initiatives. Similarly, UNESCO and OECD provide insights into digital literacy, but their models do not fully address the unique demands of aviation operations. In Indonesia, many aviation education institutions have yet to incorporate digital competencies into their curricula, despite the nation's push for digital transformation through Making Indonesia 4.0. To keep pace, educators must develop training programs that align with Industry 5.0, ensuring that future aviation workers possess advanced technological skills.

A standardized digital competency framework tailored to aviation and airport staff is essential to bridge the gap between industry needs and education systems. Without this framework, professionals may struggle to adapt to modern aviation technologies. Today's ground handling workers must excel not only in manual tasks but also in digital literacy, including proficiency in software applications, troubleshooting, and digital communication. By embracing digital transformation in training, airports can enhance operational efficiency, reduce errors, and remain competitive in the global market. This shift highlights the need to rethink training approaches and equip aviation workers with the necessary digital skills for the evolving industry.

To guarantee that aviation professionals possess uniform and current digital competencies, Aviation Education must establish standardization as one of the major producers of graduates who will be employed in the ground operations department. A comprehensive framework will define important digital skills and knowledge areas relevant to each specific role in the aviation sector. This framework will establish benchmarks for proficiency levels, facilitate targeted training programs, and enable continuous assessment and improvement of digital capabilities across the industry.

A standardized framework will address the current skills gap and prepare the future workforce for rapid technological advancements, ensuring that aviation professionals remain competitive and capable in an increasingly digitalized aviation landscape. This study aims to develop a comprehensive digital competency framework for Ground Handling.

2. RESEARCH METHOD

This study uses a qualitative approach, which allows researchers to gain an in-depth understanding of the phenomenon being studied. This approach was chosen because it provides a comprehensive picture of the actual conditions, context, and interactions that occur in the use of information technology (IT)-based facilities in the aviation world. The study is expected to reveal the challenges and opportunities in more detail with a qualitative approach.

This study was conducted in two prominent locations: Sekolah Tinggi Teknologi Kedirgantaraan (STTKD) and Yogyakarta International Airport (YIA). STTKD was chosen as the research location because it is an educational institution that produces professional personnel in the aviation field, including airport officers. Meanwhile, Yogyakarta International Airport became the research location to obtain direct data on implementing IT-based facilities in airport operations. These two locations were selected based on their relevance to the research objectives.

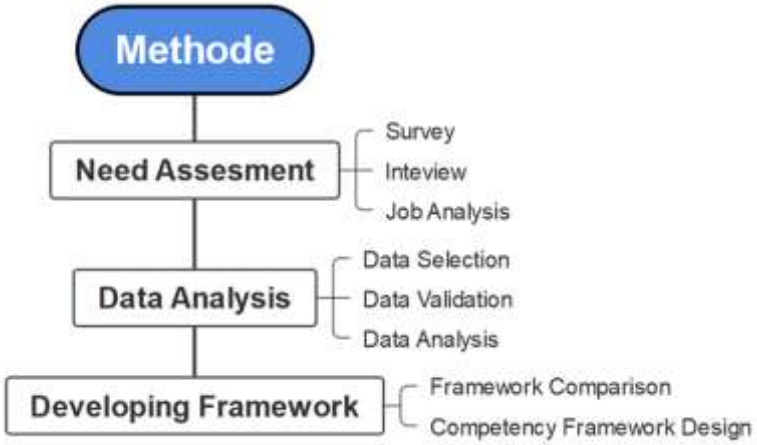

Figure 1. Research Flowchart

This research method consists of three main stages. The first stage is needs analysis, where researchers identify user needs and the role of IT-based facilities at the airport. The data collected includes technical needs, operations, and expected service quality. The second stage is data analysis, which aims to identify patterns, problems, and opportunities through the data that has been collected. The results of this analysis will be the basis for the third stage, namely the development of a framework. At this stage, researchers develop a framework that can be used to improve the effectiveness and quality of airport services.

Data were collected through two main methods: observation and interviews. Observations were made by directly observing the IT-based facilities at Yogyakarta International Airport. This process includes observations of how these facilities support airport operations, work efficiency, and user experience. In addition, in-depth interviews were conducted with supervisors and general managers at the airport to explore insights, experiences, and challenges related to implementing IT-based facilities.

Data analysis was carried out using a thematic analysis approach to identify key themes relevant to the research questions. This analysis process includes several steps: data coding, theme identification, and data interpretation. This study used a triangulation strategy to validate the data by comparing observational and interview data. In addition, discussions with experts in the aerospace field were conducted to ensure the validity of the findings.

The ethical aspect of research is also a significant concern when implementing this study. The researcher ensures that participants provide voluntary consent before participating. The confidentiality of the information participants provide is well maintained, and researchers are committed to being professional throughout the research process.

This study's research methodology involves a qualitative approach to examine how industry regulators, including IATA and national airport authorities, contribute to formulating indicators within aviation curriculum frameworks. Data collection includes reviewing relevant policy documents such as IATA's Airport Governance Toolkit and ICAO's Regulatory Framework and Organizational Structure, which outline industry standards and competency requirements for aviation professionals. Additionally, an analysis of competency assessment guidelines provided by regulatory bodies will be conducted to identify key themes in skill development and workforce training. This study employs a content analysis approach to extract insights from official publications and regulatory frameworks, ensuring that indicators used in aviation curricula reflect current technological advancements and operational demands. By synthesizing information from authoritative sources, the research aims to demonstrate how regulatory involvement

shapes training standards, ensuring alignment with industry best practices and evolving digital competencies.

3. RESULTS AND DISCUSSIONS

This research began with an initial initiation meeting aimed at preparing an in-depth activity plan. In the meeting, researchers discussed various important things, including the objectives of the research, the methodology to be used, and the targets to be achieved. This meeting was a very crucial initial step to ensure that all members of the research team had the same understanding of the direction and process of the research. In addition, in this meeting, the division of tasks was carried out so that each member of the research team could focus on their respective roles and responsibilities.

The next stage is the collection of initial data, which was carried out through direct observation in the field. This observation was carried out by observing the electronic and digital facilities available at Yogyakarta International Airport (YIA). The main focus of this observation was the areas used by the public and passengers, including the waiting room, check-in area, departure gates, and other relevant facilities. Researchers carefully documented the condition, function, and use of these facilities to get an initial picture of how technology supports airport operations.

After the observation process was completed, the research continued with the data collection stage through interviews. Interviews were conducted with parties who were considered to have relevant and in-depth information regarding airport operations. One of the interviews was conducted with officers at the check-in counter. These officers provide direct insight into the passenger service process, common obstacles, and the use of technology to support their daily work. This information is essential to understand how electronic and digital facilities are implemented in practice.

In addition, interviews were also conducted with the General Manager (GM) of YIA Airport. The GM has a broader and more strategic perspective on airport operations as a whole. In this interview, researchers explored information about the vision and mission of airport management, facility development strategies, and challenges and opportunities in facing the digitalization era. This interview provides a more comprehensive view of the direction of technology development at the airport, as well as how technology can be used to improve the passenger experience.

The documentation results show some of the digital equipment found at Yogyakarta International Airport. The digital equipment includes Flight Information Display System (FIDS), Self-Check-in Kiosk, Baggage Handling System, Public Desktop Computer, Gate Display System, Warning Receiver System, and many others.

Figure 2. FIDS

Figure 3. Baggage Handling System

Figure 4. Public Desktop Computer

Figure 5. Warning Receiver System

Based on the interview, Yogyakarta International Airport (YIA) has demonstrated its commitment to facing challenges and opportunities in the digitalization era by continuing to promote technology in various operational aspects. This step is not only aimed at improving work efficiency but also to provide the best experience for the public, passengers, and airport officers. One of the latest innovations that has been implemented is the Airport Operation Control Center (AOCC). AOCC functions as the main control center that monitors officer performance and manages passenger movement flows in real-time. With the advanced technology implemented, AOCC is able to provide important data that supports faster and more precise decision-making, thereby improving the quality of service at the airport as a whole.

It is important to note that the application of technology at the airport is not only aimed at improving operational efficiency but also to create a more comfortable experience for passengers. Technologies such as AOCC provide direct benefits to passengers, such as reduced waiting times, more responsive services, and easier access to information. In addition, technological innovation also allows airport managers to present various modern facilities, such as automatic gates, digital payment systems, and mobile applications, to make it easier for passengers to make reservations and get information related to their trips.

In the interview, it was also expressed that digital competence is now an increasingly important aspect of airport operations. Technology is no longer a compliment but has transformed into a basic need in supporting daily operations. Digital competence allows employees to adapt to various modern systems and tools used in the airport environment, from data management to automation systems in passenger services. This recognition reflects YIA's awareness of the demands of the technological era, where the ability to utilize technology is a significant factor in providing quality services.

However, the interview also revealed that expertise in information technology (IT) is currently not a top priority in the employee selection and recruitment process at YIA. Airport-related licenses remain the main focus of the recruitment process. This statement confirms that YIA, as a public facility, continues to prioritize flight operational safety and security. However, the need for IT skills is not completely ignored. Airport management is aware that technology will continue to develop, thus providing room to adjust human resource development strategies in the future.

It was also recommended that a training program tailored to digital needs be implemented. This program is designed to equip employees with basic technology skills, especially for those who will interact directly with digital facilities in their work. This training not only covers the operation of technological devices but also an understanding of the purpose and benefits of implementing the technology. This approach is expected to create a more productive work environment where employees feel confident in using technology to support their tasks.

The findings from this study emphasize the pivotal role of digital competencies in advancing operational efficiency and service quality within the aviation sector. As technology becomes an integral part of airport operations, its importance must be recognized. Participants in the study strongly acknowledged that IT skills are not just ancillary but essential for improving safety, streamlining processes, and enhancing the overall passenger experience. This result aligns with existing literature, which highlights the significant impact of technological advancements in elevating operational reliability and adherence to safety standards.

The integration of digital competencies into aviation operations is increasingly recognized as vital, particularly for ground-handling professionals. This study sheds light on key insights, challenges, and actionable recommendations in addressing the digital competency gaps, which are critical to modernizing aviation processes and aligning with industry standards.

Participants highlighted the critical role of IT skills in improving safety, streamlining operations, and delivering superior service quality. Digital tools, such as automated systems for baggage tracking, aircraft turnaround coordination, and passenger service platforms, are transforming the way ground handling personnel operate. Competency in these systems enables professionals to reduce human error, optimize workflows, and enhance communication efficiency. Moreover, technology empowers ground handling teams to respond quickly to dynamic operational demands, fostering a seamless experience for passengers and ensuring adherence to stringent safety regulations. This recognition underscores the necessity for ground-handling personnel to possess robust IT skills to navigate the complexities of aviation operations effectively.

Despite widespread acknowledgement of the importance of digital competencies, significant barriers hinder their development and implementation in the aviation sector. Participants identified limited resources for training programs as one of the primary obstacles. Airports often face budgetary constraints, leaving little room for investment in comprehensive IT skill development initiatives. Another challenge arises from resistance to change among ground-handling staff, particularly those accustomed to traditional workflows. This hesitation can delay the adoption of new technologies and diminish the overall effectiveness of training programs. Furthermore, the lack of standardized frameworks for developing digital competency creates inconsistencies in skill levels, limiting the industry's ability to implement cohesive and impactful training solutions.

To address these challenges, participants proposed designing competency-based training programs tailored to the specific needs of ground-handling roles. These programs should incorporate practical applications of IT tools such as aircraft tracking systems, automated scheduling platforms, and digital communication interfaces. By focusing on real-world scenarios, training can ensure that personnel understand not only how to operate these systems but also how to leverage them for operational efficiency and safety enhancement. Additionally, integrating IT skill development into routine staff training cycles was recommended as a sustainable approach. Regular workshops, e-learning modules, and refresher courses provide opportunities for professionals to stay updated with evolving technologies while fostering a culture of continuous learning within the workforce.

The findings of this study underscore the urgent need to bridge digital competency gaps within aviation operations. As IT-driven processes increasingly dominate the industry, the ability to utilize digital tools effectively has become indispensable for ground-handling professionals. Failure to address these gaps may lead to operational inefficiencies, reduced service quality, and compromised safety standards. These conclusions align closely with existing literature that highlights the transformative role of IT in improving reliability and safety in aviation operations. Prioritizing digital skills within workforce development strategies is therefore critical not only for immediate operational needs but also for the long-term sustainability and competitiveness of the aviation sector.

To tackle these pressing challenges, participants emphasized the need for a structured framework for developing digital competencies among prospective ground-handling professionals. Such a curriculum framework should outline clear learning objectives, incorporate hands-on training modules, and include assessments to measure progress. Collaboration with educational institutions and technology providers could enhance the curriculum by introducing cutting-edge tools and resources. Moreover, the framework should address varying levels of digital proficiency, offering foundational modules for beginners and advanced topics for experienced personnel. By formalizing digital competency development, the aviation industry can ensure a standardized approach that equips ground-handling professionals with the skills needed to thrive in a rapidly evolving technological landscape.

4. CONCLUSION

This study underscores the growing importance of digital competencies in aviation, particularly for ground handling professionals who must navigate increasingly complex technological environments. IT skills are essential for enhancing safety, optimizing workflows, and improving service quality. However, challenges such as limited resources, resistance to change, and the absence of standardized frameworks hinder widespread adoption. By integrating digital competency development into aviation training programs, the industry can create a technically proficient and adaptable workforce capable of meeting evolving operational demands. The findings emphasize the necessity of prioritizing IT skill development, as digital literacy has become a fundamental requirement rather than an optional asset. Establishing a structured curriculum framework tailored to aviation needs is crucial in ensuring workforce readiness, with standardized training modules and clear assessment criteria. This study provides a foundation for shaping national vocational education standards in Indonesia, enabling policymakers to align local training programs with global best practices. By incorporating digital competencies such as IoT-based monitoring, AI-driven diagnostics, and blockchain security applications, Indonesia's aviation sector can prepare its workforce for the future. Ultimately, investing in digital literacy ensures operational efficiency, competitiveness, and resilience in an era of rapid technological advancement.

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