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Addressing Competency Gaps in Aviation Maintenance Education: Lessons from the Philippine Experience

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Abstract

This study investigates competency gaps in the Aircraft Maintenance Technology (AMT) program of the Philippine State College of Aeronautics (PhilSCA), assessing how well the curriculum aligns with international aviation standards, including the International Civil Aviation Organization's (ICAO) Annex 1 on personnel licensing, the European Union Aviation Safety Agency's (EASA) Part 66 on aircraft maintenance licensing, and the Philippine Civil Aviation Regulations (PCAR) Part 3 governing approved training organizations. Employing a convergent mixed-methods design, the study collected data from 85 purposively selected participants, including graduates, industry professionals, and educators, between January and March 2024. Data collection involved surveys, semi-structured interviews, and curriculum document analysis to evaluate training effectiveness and graduate readiness. Results show strong curriculum alignment in foundational topics such as propulsion systems and safety documentation. However, significant gaps were identified in advanced diagnostics, avionics systems, composite materials, and essential soft skills such as communication and teamwork. Graduates who completed On-the-Job Training (OJT) in airline environments demonstrated higher job readiness than those trained in more minor Maintenance, Repair, and Overhaul (MRO) facilities. The study underscores the need to adopt competency-based education (CBE), standardize OJT placements, and deepen industry-academic partnerships. Recommendations include integrating certification pathways, expanding practical training, and establishing continuous curriculum review processes. By analyzing the Philippine experience, this study offers actionable insights for developing countries. These findings inform scalable reforms toward a globally aligned aviation workforce.

1. Introduction

Aviation maintenance is vital in ensuring aircraft's airworthiness and operational safety, serving as a foundational element of the global air transport system. With continuous technological advancements and increasingly complex aircraft systems, the industry demands highly skilled maintenance professionals capable of upholding regulatory standards and adapting to innovation. Globally, aviation safety and efficiency are maintained through harmonized regulatory frameworks, with the International Civil Aviation Organization (ICAO) providing the cornerstone through its Standards and Recommended Practices (SARPs), particularly Annex 1 on Personnel Licensing (International Civil Aviation Organization ICAO, 2018; Barrera D., 2022). Prominent aviation authorities such as

the Federal Aviation Administration (FAA) and the European Union Aviation Safety Agency (EASA) adopt ICAO's standards as the basis for their regulatory systems (Barrera, D. 2022; Witter, 2018). Furthermore, global harmonization efforts, including the US-EU Bilateral Aviation Safety Agreement, aim to reduce cross-border regulatory burdens and enhance certification efficiency (Jennison, 2013). Research shows that such alignment with international standards is associated with lower accident rates and improved aviation maintenance practices (Spence et al., 2015).

In the Philippines, the Civil Aviation Authority of the Philippines (CAAP) enforces PCAR Part 3, which governs the operations of Approved Training Organizations (ATOs) and aligns local curricula with international aviation benchmarks (Civil Aviation Authority of the Philippines, CAAP, 2024). A key example is the Aircraft Maintenance Technology (AMT) program of the Philippine State College of Aeronautics (PhilSCA), a state-run institution responsible for producing licensed maintenance technicians for domestic and international aviation markets. While the program meets regulatory requirements and is regularly audited, recent studies indicate significant competency gaps persist, particularly in advanced diagnostics, composite materials, and avionics systems (Batuwangala et al., 2016; Morrison et al., 2021).

In addition, soft skills such as communication, teamwork, and adaptability are often underemphasized in technical training programs, despite their growing recognition as essential for safe and effective maintenance operations (Bhati, 2022; Patacsil & Tablatin, 2017; Uaikhanova et al., 2024). These deficiencies are concerning, especially in a field where safety outcomes are closely tied to technical proficiency and human performance (Sirat & Harun, 2006; National Business Aviation Association [NBAA], 2024).

Competency-based education (CBE) has emerged as a promising alternative to traditional hours-based instruction in addressing these issues. Unlike conventional models, CBE focuses on performance-based outcomes and aims to align training with real-world industry demands (Kearns et al., 2016; Mendonca, 2019). It emphasizes the development of core competencies such as decision-making, leadership, communication, and technical mastery—skills considered critical in aviation maintenance environments (Keller et al., 2020; Mott et al., 2019). However, CBE implementation is not without challenges. Issues such as varying interpretations of competencies and the administrative complexity of program delivery have been reported (Hattingh et al., 2022; Franks et al., 2014), suggesting the need for clearer frameworks and better institutional support.

This study, therefore, seeks to (1) identify existing gaps in both technical and soft skills among AMT graduates in the Philippines, (2) evaluate the extent to which the current PhilSCA AMT curriculum aligns with global regulatory standards, including ICAO, EASA, FAA, and PCAR, and (3) propose strategic reforms centered on curriculum enhancement, standardized On-the-Job Training (OJT), and increased collaboration with Maintenance, Repair, and Overhaul (MRO) organizations. These objectives are informed by international best practices and the growing consensus on modernizing technical training through competency alignment (Esmail & Khan, 2024; ACTE, 2019; Alinea, 2021).

The significance of this study is twofold. At the national level, it offers evidence-based insights to guide policy decisions and educational reforms within Philippine aviation institutions. At the global level, it contributes to the broader discourse on curriculum alignment, regulatory harmonization, and competency-based models in aviation education, especially for developing countries. Prior research highlights the importance of continuous curriculum review based on labor market needs, integrating academic and technical competencies, and including global standards to ensure sustainable workforce readiness (Toroka & Kafanabo, 2024; Adelman, 1989; Sultana, 2018). By examining the Philippine experience, this study offers practical recommendations and lessons that may serve as a model for similarly situated countries aiming to strengthen their aviation maintenance training systems and improve graduate outcomes.

2. Literature Review

2.1 Global Aviation Standards and Alignment

Global aviation safety relies on harmonized regulatory frameworks established by the International Civil Aviation Organization (ICAO), whose SARPs, particularly in *Annex 1*, form the foundation for licensing aviation personnel (ICAO, 2018; Barrera, L., 2022). Regulatory bodies like the FAA and EASA adopt ICAO standards to promote consistency, reduce fatality rates, and improve maintenance practices (Witter, 2018; Spence et al., 2015). Efforts like the US–EU Bilateral Aviation Safety Agreement and initiatives from RTCA and EUROCAE support cross-border regulatory efficiency and avionics certification (Jennison, 2013; Russo, 2008; Batuwangala et al., 2016). As technologies evolve, transnational efforts have expanded to include regulatory consistency in emerging areas like drones (Morrison et al., 2021). In the Philippines, CAAP's PCAR Part 3 ensures that institutions like PhilSCA align their Aircraft Maintenance Technology (AMT) programs with international standards (CAAP, 2024).

J. of Technical Education and Training Vol. 17 No. 2 (2025) p. 165-181

2.2 Competency-Based Education in Aviation

Competency-Based Education (CBE) shifts focus from time-based instruction to demonstrated skills mastery, offering a more efficient and industry-aligned training model (Kearns et al., 2016; Martinez et al., 2019). CBE promotes core competencies such as communication, teamwork, and technical decision-making (Keller et al., 2020; Mott et al., 2019). However, implementation challenges remain, including inconsistent definitions, administrative demands, and instructional gaps (Hattingh et al., 2022; Franks et al., 2014). Despite critiques, CBE is recognized as a promising solution to workforce gaps in aviation maintenance (Book, 2014; Mendonca, 2019).

2.3 Soft Skills and Advanced Diagnostics

Soft skills are essential across technical fields, enhancing teamwork, leadership, and professional adaptability (Costantino & Rodzinka, 2022; Bhati, 2022; Ibrahim & Abiddin, 2024). In aviation, soft skills are especially critical for safety through effective Crew Resource Management (CRM) (NBAA, 2024; Oaklands Global, 2024). Simultaneously, modern aircraft systems demand advanced diagnostic skills for accurate fault detection and resolution (Copernicus Technology, 2025). As a result, maintenance programs integrate soft skill development and diagnostic training to meet evolving industry expectations (National Aviation Academy, 2024; Patacsil & Tablatin, 2017).

2.4 Curriculum Alignment in Technical Education

Curriculum alignment ensures that technical programs remain relevant to labor market needs. Effective alignment integrates academic knowledge with technical competencies, certifications, and digital literacy (ACTE, 2019; ISTE, n.d.). Models such as backward design and digital curriculum mapping support structured program development (University of Colorado Boulder, n.d.; Khoerunnisa et al., 2018). Empirical studies show alignment improves employability and academic performance (Squires, 2012; Alinea, 2021), though challenges persist in many contexts, including outdated content and lack of industry input (Toroka & Kafanabo, 2024; Adelman, 1989). Continuous curriculum review, informed by labor market data and stakeholder feedback, remains essential (Sultana, 2018).

3. Methodology

3.1 Research Design

This study employed a convergent mixed methods design to comprehensively examine competency gaps in aviation maintenance education and curriculum alignment with industry standards. Quantitative data from graduate surveys and qualitative data from interviews with educators, regulators, and industry professionals were collected simultaneously, analyzed separately, and integrated during interpretation to strengthen the validity of findings. The Aircraft Maintenance Technology (AMT) program at the Philippine State College of Aeronautics (PhilSCA) was evaluated against local regulations under the Philippine Civil Aviation Regulations (PCAR) Part 3 and global benchmarks from the International Civil Aviation Organization (ICAO) Annex 1 and European Union Aviation Safety Agency (EASA) Part 66 standards. Curriculum analysis employed a Gap Analysis Framework and Competency-Based Education (CBE) Mapping, adapted from ICAO's Human Resources Development strategies and the ICAO Manual on Competency-Based Training (Doc 9868), ensuring a systematic and internationally grounded assessment of curriculum effectiveness and workforce readiness.

3.2 Gap Analysis and CBE Mapping

The Gap Analysis Framework identified discrepancies between the curriculum and industry benchmarks, highlighting areas where competency development needed improvement. For example, while many components were "Fully Aligned," others, such as advanced diagnostics and emerging technologies, were identified as gaps requiring enhancement. CBE Mapping aligned specific courses with technical and soft skills outlined in PCAR Part 3 and ICAO Annex 1 standards. This process ensured that the curriculum was evaluated for content coverage and its ability to foster essential competencies for workforce readiness.

3.3 Participants and Sampling

The study involved 85 participants, selected through purposive sampling to ensure relevance to aviation maintenance education and industry standards. Participants were categorized into three groups: 50 aviation maintenance graduates, 25 industry professionals, and 10 educators and regulatory officials. Graduates were selected based on their completion of an Aircraft Maintenance Technology (AMT) program and On-the-Job

Training (OJT) at Maintenance, Repair, and Overhaul (MRO) facilities or airline maintenance departments. They provided insights into academic preparation, technical skill development, and workforce integration challenges.

Industry professionals from MROs and airlines included human resource specialists, technical supervisors, and quality assurance officers. Their input was essential for assessing curriculum relevance and identifying competency gaps. Educators and regulators were affiliated with the Philippine State College of Aeronautics (PhilSCA) and the Civil Aviation Authority of the Philippines (CAAP), offering perspectives on curriculum design, regulatory compliance, and alignment with international standards. This sampling approach ensured the inclusion of stakeholders with direct experience in training, regulation, and employment, supporting the study's goal of evaluating curriculum effectiveness and workforce readiness.

3.4 Data Collection

Data were collected over three months, from January to March 2025, using three primary methods: surveys, semi-structured interviews, and curriculum analysis. Surveys were administered to aviation maintenance graduates to gather quantitative data regarding their perceptions of curriculum effectiveness, technical and soft skill development, and employment challenges. Before distribution, the survey instrument was pilot-tested with a small group of graduates to ensure clarity, relevance, and reliability; necessary adjustments were made based on their feedback. These validated surveys provided measurable insights into graduates' preparedness for industry demands.

Semi-structured interviews were conducted with educators, regulators, and industry professionals to obtain qualitative insights into competency gaps, curriculum alignment, and areas for improvement. Two subject matter experts reviewed the interview guide to enhance content validity and ensure the questions aligned with the study objectives. This method enabled an in-depth exploration of diverse stakeholder perspectives. Finally, a comprehensive review of PhilSCA's Aircraft Maintenance Technology (AMT) curricula was undertaken to evaluate compliance with regulatory standards, particularly PCAR Part 3, and alignment with international benchmarks such as ICAO Annex 1, IATA guidelines, and EASA standards.

3.5 Evaluating Curriculum Alignment

Evaluating curriculum alignment with global aviation industry benchmarks involved a systematic approach using a Gap Analysis Framework and Competency-Based Education (CBE) Mapping. The primary benchmarks were regulatory standards, including PCAR Part 3 Approved Training Organization Curriculum Requirements. Official curriculum documents, course syllabi, and credit hour allocations were analyzed and compared against these benchmarks using a comparison matrix. Each curriculum component was assessed for alignment and categorized as "Fully Aligned," "Partially Aligned," or "Not Evaluated." Thematic analysis of semi-structured interviews with educators, industry professionals, and CAAP officials complemented this process, providing qualitative insights into the curriculum's relevance and areas of enhancement. Stakeholders identified technical and soft skill gaps, such as advanced diagnostics, avionics expertise, communication, and teamwork, that required attention in the curriculum.

3.6 Data Analysis

The study used quantitative and qualitative data analysis to assess curriculum effectiveness and competency gaps comprehensively. Descriptive statistics, including central tendency and dispersion measures, were used to summarize graduates' perceptions of relevance to technical training, soft skills development, and OJT experiences. Frequency distributions and percentages were calculated to highlight specific challenges, and results were presented through bar and pie charts.

Inferential statistics were applied to strengthen the analysis. Independent samples t-tests compared perceptions between graduates from airline and MRO OJT settings, while one-way ANOVA assessed variations across demographic groups. Statistical significance was set at $p < 0.05$, and analyses were performed using IBM SPSS Statistics version 28.

For qualitative data, thematic analysis was conducted using NVivo 14 software. Two independent researchers coded the interview transcripts, achieving substantial inter-coder reliability measured through Cohen's kappa coefficient. The members checked with the participants to validate the emerging themes further. Quantitative and qualitative findings were synthesized to evaluate the alignment of PhilSCA's AMT programs with regulatory standards and industry expectations.

3.7 Ethical Consideration

This study adhered to ethical research principles, ensuring voluntary participation, informed consent, confidentiality, and data protection. Participants, including graduates, educators, and industry professionals, were informed of the study's purpose, their right to withdraw, and the measures taken to safeguard their identities. No

personal or sensitive data was collected beyond the scope necessary for research objectives. The study followed ethical guidelines following institutional and regulatory standards, ensuring integrity, transparency, and respect for all participants.

4. Results and Discussion

4.1 Demographics of Participants

The demographic analysis (Figure 1) highlights an intense concentration of aviation activities and expertise in Metro Manila and Clark, with 50% of graduates and 80% of industry professionals based in these hubs. This geographic trend reflects the centralization of aviation infrastructure and employment opportunities in major urban centers. Educationally, while 90% of graduates completed introductory aviation maintenance courses, only 40% pursued specialized certifications, and 60% engaged in postgraduate training, indicating a need for broader advanced skill development.

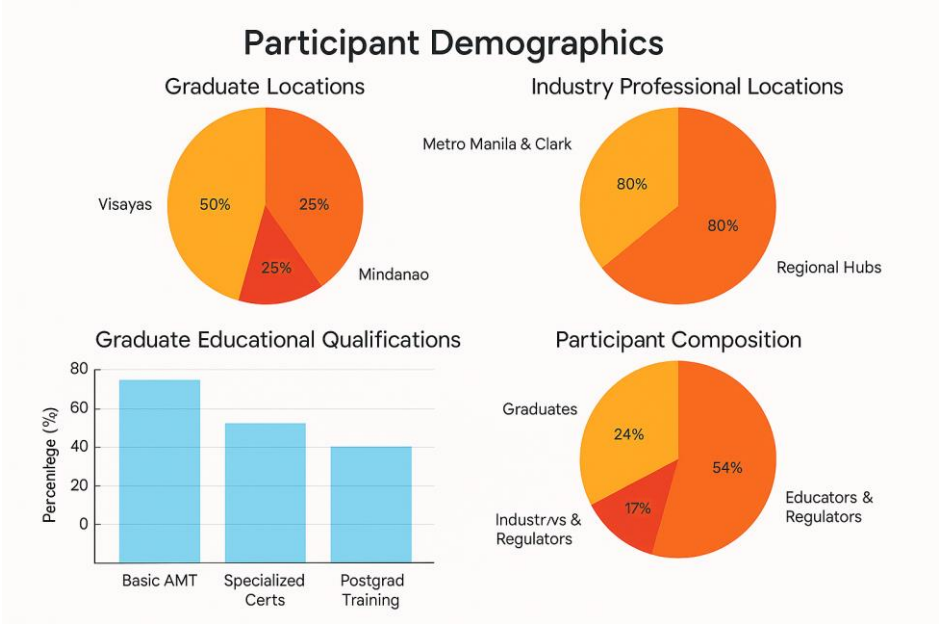

Fig. 1 *Participant demographics by location, education, and role in aviation maintenance education evaluation*

The participant composition, as shown in Figure 1, was well-balanced, with graduates comprising the majority (58.8%), supported by industry professionals (29.4%) and educators and regulators (11.8%), ensuring diverse stakeholder representation. Most graduates (70%) completed OJT in MRO settings, with a smaller proportion (30%) gaining exposure in airline environments, suggesting variability in training quality. The demographic distribution (Figure 1) provides a strong foundation for assessing competency gaps, curriculum alignment, and the need for expanded industry collaboration in aviation maintenance education.

4.2 Subgroup Comparisons

Table 1 *Statistical comparison summary of participant subgroups, highlighting key areas of competency assessment and the tests used to evaluate differences in aviation maintenance training outcomes*

Comparison Focus	Subgroups Compared	Statistical Test Used	Purpose of Test
Job Readiness	MRO vs. Airline OJT	Independent Samples t-test	Assess differences in graduate confidence and perceived preparedness for employment.
Diagnostic Skill Ratings	With vs. Without Certifications	Independent Samples t-test	Examine the impact of specialized certifications on diagnostic performance.
Soft Skill Development	Metro Manila vs. Visayas/Mindanao	One-Way ANOVA	Identify regional disparities in soft skill development and training outcomes.

Table 2 *Effect sizes for subgroup comparisons on job readiness, diagnostic skills, and soft skill development, highlighting the practical significance of training context and certification in aviation maintenance education*

Comparison	Group 1 (M, SD)	Group 2 (M, SD)	Test Used	Effect Size	Interpretation
Job Readiness (Airline vs. MRO)	65 (15)	45 (20)	Independent Samples t-test	Cohen's d = 1.13	Large effect
Diagnostic Skills (Certified vs. Not)	75 (12)	60 (15)	Independent Samples t-test	Cohen's d = 1.10	Large effect
Soft Skills by Region	Metro Manila vs. Others	–	One-Way ANOVA	$\eta^2 = 0.045$	Small-to-moderate effect

Table 1 presents the subgroup comparisons conducted to identify significant differences in graduate outcomes based on training context and demographic variables. An independent samples t-test revealed that graduates who completed On-the-Job Training (OJT) in airline maintenance settings reported significantly higher job readiness scores than those trained in small to medium-sized Maintenance, Repair, and Overhaul (MRO) facilities. This finding suggests that training environments with advanced infrastructure and exposure to larger-scale operations may better equip students for industry demands.

A second t-test comparing diagnostic skill ratings showed that graduates with specialized certifications performed significantly better in advanced troubleshooting tasks than those without. This highlights the importance of integrating industry-recognized certifications into the formal curriculum to enhance technical proficiency. A one-way ANOVA examining soft skill development across geographic regions indicated that graduates from Metro Manila exhibited slightly higher communication and adaptability scores than their counterparts from Visayas and Mindanao. However, the differences were not statistically significant. These findings suggest that access to diverse workplace dynamics and institutional resources may influence non-technical competency development.

Effect size analysis (Table 2) further reinforces the practical relevance of these differences. The comparison of job readiness scores between airline-trained and MRO-trained graduates yielded a Cohen's d of 1.13, indicating a large effect size and demonstrating the substantial impact of training environment quality. Similarly, the effect size for diagnostic performance between certified and non-certified graduates was also large (Cohen's d = 1.10), supporting the integration of specialized certification tracks into AMT programs. In contrast, the η^2 value of 0.045 for soft skills across regions suggests a small to moderate effect, implying that regional variation is more limited than training content or delivery. These results collectively emphasize the importance of curricular enhancements, standardized training experiences, and competency-based frameworks to ensure technical and soft skill readiness among aviation maintenance graduates.

4.3 Curriculum Alignment

Table 3 compares the PCAR part 3 curriculum requirements with PhilSCA's Aircraft Maintenance Technology (AMT) program, demonstrating substantial compliance with local and international aviation standards. While the curriculum effectively covers foundational areas such as basic electricity, weight and balance, and reciprocating/turbine engines, specific specialized topics require further integration to meet evolving industry demands. Gaps exist in areas such as fluid lines and fittings, wood structures, engine instrument systems, and fuel metering systems, which are either partially addressed or not explicitly included. Additionally, while Mathematics is part of the curriculum, its depth and application may not fully meet PCAR standards, requiring adjustments to enhance technical problem-solving skills.

J. of Technical Education and Training Vol. 17 No. 2 (2025) p. 165-181

Table 3 *Comparison of PCAR part 3 curriculum requirements and PhilSCA aircraft maintenance technology curriculum*

Curriculum Component	PCAR Hours	PhilSCA Coverage	Alignment Status
Basic Electricity	30	Covered under Aircraft Electrical and Ignition Systems (2 Lec, 3 Lab)	Fully Aligned
Aircraft Drawings	40	Covered under Engineering Drawing and Mechanical Drawing (6 Lab)	Fully Aligned
Weight and Balance	30	Covered under Aircraft Weight and Balance and Load Control (1 Lec, 3 Lab)	Fully Aligned
Fluid Lines and Fittings	15	Covered under Aircraft System (3 Lec, 3 Lab)	Fully Aligned
Materials and Processes	50	Covered under Aircraft Materials Construction and Repair I & II	Fully Aligned
Ground Operation and Servicing	30	Covered under Aircraft Maintenance Inspection and Servicing (3 Lec, 3 Lab)	Fully Aligned
Cleaning and Corrosion Control	30	Covered under Corrosion Protection and Control (1 Lec, 3 Lab)	Fully Aligned
Mathematics	75	Covered under Mathematics in Modern World (3 Lec)	Partial Alignment
Maintenance Forms and Records	40	Covered under Aircraft Manuals, Catalogs, and Documentation (1 Lec, 3 Lab)	Fully Aligned
Maintenance Publications	50	Covered under Aircraft Manuals, Catalogs, and Documentation	Fully Aligned
Mechanic Privileges and Limitations	20	Covered under Air Laws and Civil Air Regulations (3 Lec)	Fully Aligned
Wood Structures	15	Not explicitly listed	Not Evaluated
Aircraft Covering	15	Not explicitly listed	Not Evaluated
Aircraft Finishes	30	Not explicitly listed	Not Evaluated
Sheet Metal and Nonmetallic Structures	60	Covered under Aircraft Materials Construction and Repair I & II	Fully Aligned
Welding	70	Not explicitly listed	Not Evaluated
Assembly and Rigging	50	Covered under Aircraft Flight Controls (1 Lec, 3 Lab)	Fully Aligned
Airframe Inspection	40	Covered under Aircraft Maintenance Inspection and Servicing	Fully Aligned
Aircraft Landing Gear Systems	30	Covered under Aircraft Structures and Landing Gears (1 Lec, 3 Lab)	Fully Aligned
Hydraulic and Pneumatic Power Systems	20	Covered under Aircraft Environment and Auxiliary Systems (2 Lec, 3 Lab)	Fully Aligned
Cabin Atmosphere Control Systems	60	Covered under Aircraft Environment and Auxiliary Systems	Fully Aligned
Aircraft Instrument Systems	20	Covered under Aircraft Instrument Systems (1 Lec, 3 Lab)	Fully Aligned
Communication and Navigation Systems	30	Covered under Communication and Navigation Systems (1 Lec, 3 Lab)	Fully Aligned
Aircraft Fuel Systems	70	Covered under Aircraft Fuels and Lubricants (1 Lec, 3 Lab)	Fully Aligned
Aircraft Electrical Systems	50	Covered under Aircraft Electrical and Ignition Systems	Fully Aligned

Position and Warning Systems	50	Covered under Aircraft Environment, Auxilliary and Communication and Navigation System (3 Lec, 6 Lab)	Fully Aligned
Ice and Rain Control Systems	40	Covered Under Aircraft Environment and Auxiliary System (1 Lec 3 Lab)	Fully Aligned
Fire Protection Systems	70	Covered under Aviation Safety and Aircraft Environment and Auxiliary System (5 Lec, 3 Lab)	Fully Aligned
Reciprocating Engines	80	Covered under Aircraft Powerplant I (3 Lec, 3 Lab)	Fully Aligned
Turbine Engines	80	Covered under Aircraft Powerplant II (3 Lec, 3 Lab)	Fully Aligned
Engine Inspection	80	Covered under Aircraft Powerplant Overhaul (3 Lec, 3 Lab)	Fully Aligned
Engine Instrument Systems	50	Covered under Aircraft Instruments (1 Lec, 3 Lab)	Fully Aligned
Engine Fire Protection Systems	40	Covered under Aircraft Environment and Auxiliary System (2 Lec, 3 Lab)	Partial Alignment
Engine Electrical Systems	30	Covered under Aircraft Electrical and Ignition Systems	Fully Aligned
Lubrication Systems	30	Covered under Aircraft Fuels and Lubricants	Fully Aligned
Ignition and Starting Systems	50	Covered under Aircraft Electrical and Ignition Systems	Fully Aligned
Fuel Metering Systems	60	Aircraft Fuels and Lubricants (1 Lec, 3 Lab)	Fully Aligned
Propellers	60	Covered under Aircraft Propeller (1 Lec, 3 Lab)	Fully Aligned
OJT	Required	Included in the Fourth Year	Fully Aligned

PhilSCA's On-the-Job Training (OJT) program aligns with PCAR standards, ensuring hands-on experience. However, inconsistencies in placement quality affect uniform skill development among graduates. Strengthening industry partnerships and standardizing OJT practices would enhance training effectiveness and provide exposure to modern aircraft technologies. While PhilSCA's AMT curriculum meets most PCAR requirements, targeted improvements in specialized technical training and practical applications are essential for complete alignment with global aviation industry expectations.

4.4 Alignment with International Standards

Table 4 evaluates how PhilSCA's Aircraft Maintenance Technology (AMT) curriculum aligns with PCAR part 3 standards and global aviation benchmarks. While key competencies such as basic electricity, weight and balance, reciprocating/turbine engines, and documentation and record-keeping meet regulatory and industry expectations, gaps remain in specialized areas requiring curriculum enhancements. The most critical deficiencies include aircraft instrument systems, which lack sufficient practical training in modern avionics, and structural repairs, which primarily focus on traditional materials rather than composite repair techniques used in modern aircraft. Advanced diagnostics remains a significant gap, as graduates have limited exposure to fault isolation and troubleshooting techniques necessary for maintaining sophisticated aircraft systems.

J. of Technical Education and Training Vol. 17 No. 2 (2025) p. 165-181

Table 4 *Structured overview of the alignment status of key curriculum components with international standards, highlighting both strong areas and those requiring improvement*

Category	Curriculum Component	Alignment Status	Remarks
Areas of Strong Alignment	Basic Electricity	Fully Aligned	Meets both PCAR Part 3 and global benchmarks.
	Weight and Balance	Fully Aligned	Comprehensive coverage in theoretical and practical applications.
	Reciprocating/Turbine Engines	Fully Aligned	The curriculum prepares graduates adequately for propulsion system maintenance.
	Documentation and Record-Keeping	Fully Aligned	Meets international standards for regulatory compliance.
Areas Requiring Improvement	Aircraft Instrument Systems	Partially Aligned	Limited practical training; needs enhancement to align with modern trends.
	Structural Repairs	Partially Aligned	Focus on traditional materials is sufficient, but composite repair techniques require improvement.
	Advanced Diagnostics	Not Fully Aligned	Significant gaps in advanced fault isolation and troubleshooting techniques.
On-the-Job Training (OJT)	Practical Training Placements	Fully Aligned	OJT aligns well with PCAR and ICAO standards, but variability in placement quality impacts consistency.

Although On-the-Job Training (OJT) aligns with PCAR and ICAO standards, inconsistencies in placement quality affect uniform skill acquisition. Some students gain robust industry-relevant training, while others have limited exposure to advanced aircraft technologies. Strengthening partnerships with leading MROs and airlines and standardizing OJT experiences can help bridge these disparities. To fully align with global aviation standards, continuous curriculum improvements, adoption of international best practices, and stronger industry-academic collaboration are essential. These efforts will enhance graduate competency and ensure competitiveness in the evolving aviation industry.

4.5 Technical Skills

Table 5 highlights key competency gaps in technical skills among aircraft maintenance graduates, identifying areas of strength and those requiring significant improvement. The findings indicate that advanced diagnostic skills, troubleshooting and problem-solving, and structural repairs present critical gaps. Employers (70%) and graduates (60%) cited deficiencies in advanced fault isolation and modern diagnostic techniques, emphasizing the need for updated training on evolving aircraft technologies. Additionally, 68% of employers identified troubleshooting as requiring enhanced hands-on training, while structural repairs need greater emphasis on composite materials to align with modern industry demands.

Table 5 *Competency gaps in technical skills among aircraft maintenance graduates, aligned with industry expectations*

Technical Skills	Percentage of Graduates Identifying Gap (%)	Percentage of Employers Identifying Gap (%)	Alignment Status	Remarks
Proficiency in Using Aircraft Maintenance Tools and Equipment	40	45	Partially Aligned	Insufficient practical tool handling
Comprehensive Understanding of Aircraft Systems	50	55	Partially Aligned	Requires a deeper understanding of hydraulic and electrical systems
Knowledge of Aircraft Design and Control Systems	45	50	Partially Aligned	Limited exposure to modern control systems
Ability to Read, Interpret, and Apply Technical Drawings and Blueprints	35	40	Partially Aligned	Requires more focus on blueprint interpretation during training
Familiarity with Aircraft Components	38	42	Partially Aligned	Inadequate exposure to emerging technologies like composites
Competency in Reading and Interpreting Technical Manuals	30	35	Partially Aligned	Difficulty in interpreting complex instructions
Proficiency in Troubleshooting and Problem-Solving	60	68	Not Fully Aligned	Significant gap in advanced troubleshooting techniques
Expertise in Maintenance Procedures	48	55	Partially Aligned	Limited practice with real-world scenarios
Knowledge of Safety Protocols and Standards	28	30	Fully Aligned	Meets safety standards, but needs refreshers
Inspection Techniques	40	45	Partially Aligned	Gaps in practical inspection training.
Knowledge of Propulsion Systems	50	60	Partially Aligned	Insufficient engine system troubleshooting skills
Documentation and Record-Keeping	35	40	Fully Aligned	Graduates meet basic documentation needs
Ability to Conduct Weight and Balance Calculations	25	30	Fully Aligned	Graduates exhibit adequate knowledge
Calibration of Test Equipment	42	50	Partially Aligned	Insufficient practice in test equipment calibration
Environmental Systems Maintenance	38	45	Partially Aligned	Limited training on cabin pressurization and climate systems
Advanced Diagnostic Skills	60	70	Not Fully Aligned	Significant gaps in fault isolation for modern systems
Hydraulic and Pneumatic Systems Maintenance	50	58	Partially Aligned	Requires advanced system maintenance skills
Structural Repairs	55	63	Partially Aligned	Limited knowledge of composite material repairs

J. of Technical Education and Training Vol. 17 No. 2 (2025) p. 165-181

Other technical competencies, such as calibration of test equipment, environmental systems maintenance, and hydraulic and pneumatic systems maintenance, exhibit partial alignment with industry needs. These areas require additional practical training to strengthen graduates' proficiency in maintaining and troubleshooting essential aircraft systems. Similarly, foundational skills like aircraft maintenance tools proficiency, aircraft systems knowledge, and propulsion systems understanding are only partially aligned due to limited practical exposure and restricted access to advanced aircraft control and propulsion technologies.

Despite these gaps, the study identified areas of full alignment, including safety protocols, documentation and record-keeping, and weight and balance calculations, where graduates meet employer and regulatory standards. However, even these well-aligned areas could benefit from periodic refresher training to ensure continued relevance in a rapidly evolving industry. Addressing these competency gaps through enhanced hands-on training, exposure to modern aircraft technologies, and structures industry partnership is crucial for improving workforce readiness in aviation maintenance.

4.6 Soft Skills

Figure 2 illustrates the identified gaps in soft skills among aviation maintenance graduates, as both graduates and employers reported. Communication skills emerged as the most significant soft skill gap, with 70% of employers and 55% of graduates acknowledging their inadequacy. This highlights the critical need for improved training and exposure to communication practices within the workplace, which is essential for effective collaboration, documentation, and adherence to safety protocols in the aviation industry. Teamwork and collaboration were also identified as significant areas of concern, with 60% of employers and 48% of graduates reporting deficiencies.

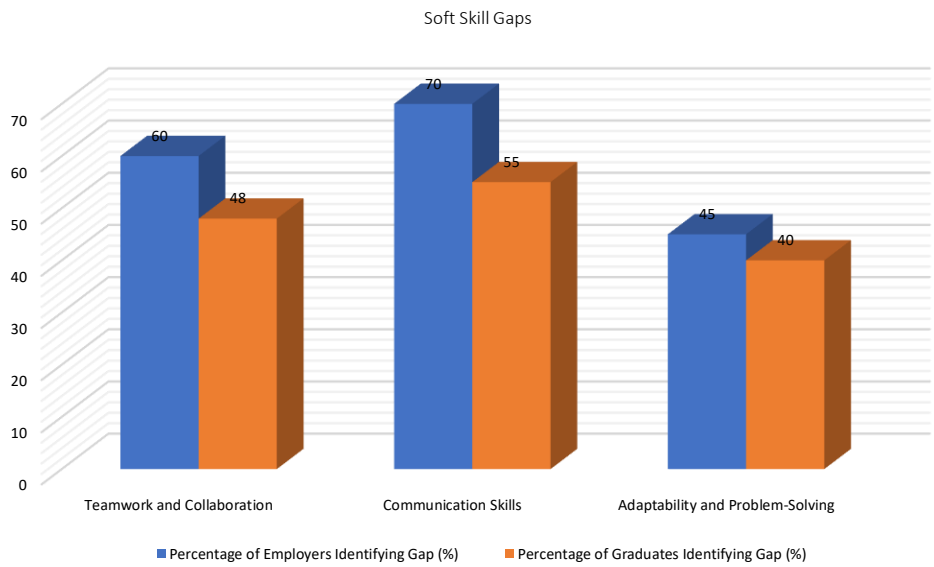

Fig. 2 *Soft skill gaps identified by employers and graduates*

This suggests that graduates may struggle to function effectively within team-based environments, a skill crucial in aviation maintenance, where collaboration is vital for ensuring safety and operational efficiency. Adaptability and problem-solving skills were identified as moderate gaps, with 45% of employers and 40% of graduates noting weaknesses. This points to the need for more emphasis on teaching graduates how to navigate dynamic work environments and resolve complex issues, particularly in fields that require quick, accurate responses to technical challenges.

Figure 3 presents a comparative evaluation of the effectiveness of OJT placements between airline settings and small to medium-sized MROs. The data, drawn from graduate and employer surveys, reveal a notable disparity in training outcomes. While 70% of graduates completed OJT in MROs, only 45% reported feeling job-ready, and 60% of employers indicated that further training was required post-placement. In contrast, airline-trained graduates, comprising just 30% of the sample, reported higher job readiness (65%) and received more favorable evaluations from employers, with 55% rated as immediately employable.

The differences also extend to technical skill development. Employers noted diagnostic skill gaps in 60% of MRO-trained graduates, compared to 45% among airline-trained counterparts. This suggests that exposure to complex systems and structured workflows during OJT is critical in cultivating higher-order maintenance competencies.

Despite these differences, both groups displayed deficiencies in soft skills, with 50% of graduates identifying communication, teamwork, and adaptability as areas needing improvement. These results underscore the importance of embedding structured soft skill development within OJT programs. Standardizing OJT practices, particularly through competency-based frameworks aligned with FAA Part 147 and EASA models, is essential to ensure consistent training quality and prepare graduates for dynamic, safety-critical aviation environments.

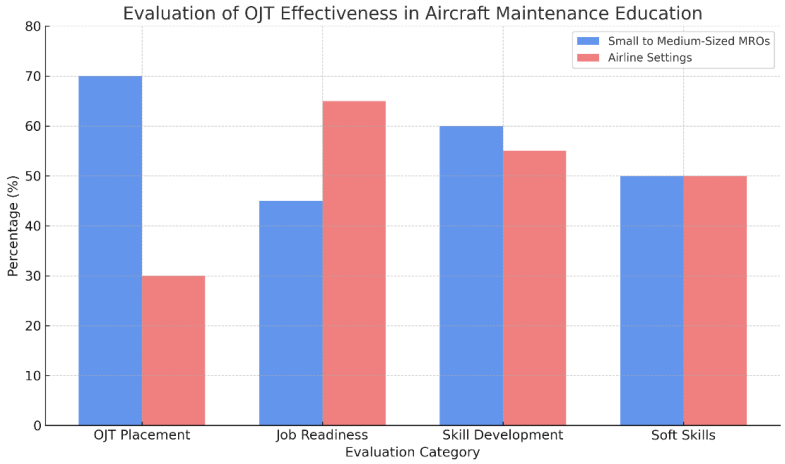

Fig. 3 *Comparative evaluation of on-the-job training (OJT) effectiveness in aircraft maintenance education, highlighting differences in placement, job readiness, skill development, and soft skills between minor to medium-sized MROs and airline settings*

4.7 Global Lessons from the Philippine Case

The evaluation of PhilSCA's Aircraft Maintenance Technology (AMT) program highlights valuable lessons for advancing aviation maintenance education globally. Aligning with standards such as ICAO Annex 1 and EASA Part 66 demonstrates that compliance with international benchmarks enhances graduate employability and ensures readiness for domestic and global industry demands. While foundational areas like basic electricity, propulsion systems, and weight and balance are well-integrated, the curriculum requires targeted improvements in advanced diagnostics, avionics, and composite repairs. Addressing these gaps through modernized training content and technology integration is essential for meeting the evolving demands of the aviation sector.

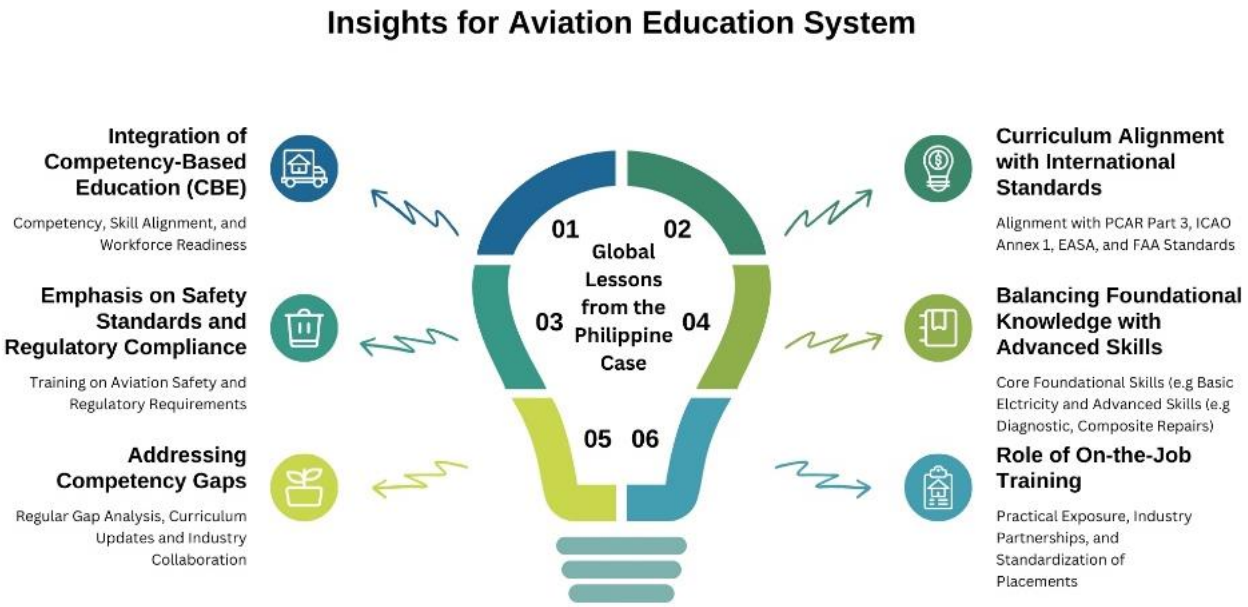

Fig. 4 *Global lessons from the Philippine case: insights for aviation education systems*

In addition, variability in On-the-Job Training (OJT) quality underscores the need for standardized frameworks modeled on globally recognized systems such as FAA Part 145 and EASA Part 147. Implementing structured OJT protocols can ensure consistent technical exposure and strengthen skill acquisition.

The Philippine case also reinforces the value of embedding safety protocols throughout training and adopting Competency-Based Education (CBE) to align learning outcomes with real-world aviation practices. Global lessons from the Philippine aviation education system highlight key strategies such as competency-based education, curriculum alignment, safety compliance, and standardized OJT for improving workforce readiness. These approaches collectively contribute to a workforce that is both technically proficient and adaptable to dynamic industry needs. As illustrated in **Figure 4**, the Philippine experience offers a scalable model for education reform in developing countries. Strengthening collaboration among training institutions, regulatory bodies, and industry stakeholders is essential to institutionalize curriculum improvement and enhance global workforce readiness.

4.8 Comparison with Related Studies

This study builds on existing research on competency gaps, OJT, and curriculum alignment in aviation maintenance education. Like Suyitno et al. (2021), who emphasized the role of industrial training in workforce readiness, this study highlights OJT as essential for skill development. However, variability in OJT quality remains a challenge, with graduates from airline settings demonstrating higher proficiency than those trained in small-to-medium-sized MROs, reinforcing the need for standardized OJT practices.

Soft skills gaps, particularly in communication and teamwork, also align with previous findings in aviation training. This study underscores the importance of Competency-Based Education (CBE) in bridging these gaps by integrating both technical and non-technical competencies into the curriculum. Unlike broader STEM and technical education studies, this research focuses on aviation maintenance, confirming strong curriculum alignment in basic electricity and propulsion systems while identifying gaps in advanced diagnostics and composite repairs. These findings suggest competency mapping and targeted curriculum enhancements can better prepare aviation maintenance graduates for industry demands and global workforce expectations.

4.9 Implications for Global Curriculum Reform

Integrating advanced training, certifications, and soft skill development into global curricula is essential to address competency gaps in aviation maintenance. Specialized certifications in composite repair, advanced diagnostics, and hands-on training with emerging technologies should be prioritized. Workshops, role-playing scenarios, and structured industry seminars can strengthen communication, teamwork, and adaptability skills.

Collaboration with stakeholders, including MROs, airlines, and regulatory bodies such as ICAO and EASA, is crucial for aligning curricula with industry demands. Standardizing OJT placements and involving industry professionals in curriculum design can ensure relevance and adaptability to evolving technologies and regulatory requirements. Establishing global benchmarks and sharing best practices among institutions will further elevate the standardization and effectiveness of aviation education worldwide.

4.10 Localized Context as a Case Study

The Philippine case provides a valuable model for addressing competency gaps in aviation maintenance education, particularly in developing countries with similar challenges. By aligning its curriculum with the standards set by the Civil Aviation Authority of the Philippines (CAAP) and the Philippine Civil Aviation Regulations (PCAR) Part 3, the Philippine State College of Aeronautics (PhilSCA) demonstrates how adherence to local and international benchmarks can create a foundation for workforce readiness. This alignment ensures compliance with regulatory requirements and industry needs, offering a practical template for other nations seeking to enhance aviation education. Integrating On-the-Job Training (OJT) into the curriculum further highlights the importance of industry partnerships. While variability in placement quality remains a concern, the emphasis on hands-on experience equips graduates with practical skills crucial for employability. Developing countries can adopt similar approaches by collaborating with Maintenance, Repair, and Overhaul (MRO) facilities and airlines to enhance OJT effectiveness.

Moreover, the Philippine approach underscores the need to address soft skill gaps and expand advanced technical training, such as composite repair and modern diagnostics. The Philippines provides a roadmap for balancing foundational knowledge with evolving industry demands through regular curriculum reviews, stakeholder consultations, and competency-based education mapping. This case demonstrates the importance of leveraging regulatory compliance, industry collaboration, and practical training to create an aviation education system that meets global and local standards.

5. Conclusion

This study examined competency gaps, curriculum alignment, and the effectiveness of on-the-job training (OJT) in aviation maintenance education, using the Philippine State College of Aeronautics (PhilSCA) as a case study. The findings revealed that while foundational topics such as propulsion systems, weight and balance, and documentation are well-aligned with PCAR Part 3 and global benchmarks, critical gaps persist in advanced diagnostics, composite material repairs, and modern instrumentation. Additionally, soft skills such as communication, teamwork, and adaptability remain underdeveloped, emphasizing the need for their integration into curricula. OJT was identified as a vital bridge between academic learning and practical application; however, inconsistencies in placement quality underscore the need for standardization and stronger industry collaboration.

The findings of this study hold significant global relevance, as the challenges identified in the Philippine aviation maintenance education system reflect broader issues faced by training organizations worldwide. The results highlight the importance of aligning curricula with evolving industry demands, integrating advanced technical training, and emphasizing soft skill development to better prepare graduates for the dynamic and global aviation sector. Addressing these challenges requires international collaboration among academic institutions, regulatory bodies, and Maintenance, Repair, and Overhaul (MRO) organizations. Such partnerships can ensure that aviation maintenance education consistently aligns with global industry requirements, fostering a competent and job-ready workforce.

Future research should explore the long-term impact of curriculum reforms on graduate employability and industry performance. Comparative studies across multiple countries could provide valuable insights into best practices and shared challenges in aviation education. By building on the findings of this study, the aviation industry and educational institutions can work together to establish a globally standardized and practical framework for aviation maintenance education. Although this study focuses on aviation maintenance education in the Philippines, its findings widely apply to training organizations worldwide. The challenges identified—competency gaps in advanced diagnostics, structural repairs, and soft skills—mirror those faced by Approved Training Organizations (ATOs) in other developing regions. Strengthening curriculum alignment with ICAO Annex 1, standardizing OJT placements, and fostering industry partnerships are global imperatives for aviation education reform. This research serves as a blueprint for enhancing workforce readiness, ensuring that graduates from aviation maintenance programs worldwide can meet the industry's evolving demands.

5.1 Recommendations

To enhance aviation maintenance education and address identified competency gaps, this study proposes short-term and long-term recommendations to improve curriculum alignment, training quality, and workforce readiness in line with global aviation industry standards.

5.1.1 Short-Term

- In the immediate term, institutions should focus on practical interventions that can directly improve graduate competencies and training experiences:
- Integrate industry-recognized certifications (e.g., Airbus, Boeing, IATA) into the curriculum to provide students with internationally recognized credentials that enhance employability.
- Expand hands-on training with modern aircraft technologies, especially in composite material repairs and advanced diagnostic tools.
- Adopt Competency-Based Education (CBE) models that ensure structured, measurable development of technical and soft skills, including communication, adaptability, and teamwork.
- Standardize On-the-Job Training (OJT) placements by aligning with current best practices and regulatory expectations, ensuring consistent exposure to advanced maintenance environments.
- Strengthen partnerships with Maintenance, Repair, and Overhaul (MRO) facilities and airlines to improve training quality, facilitate internships, and allow for industry feedback in curriculum design.

5.1.2 Long-Term

- Institutionalize regular curriculum review cycles to align academic programs with evolving global aviation standards, particularly ICAO Annex 1 and EASA Part 66.
- Develop regional centers of excellence for advanced maintenance training, specializing in emerging areas such as aircraft electrification, digital avionics, and predictive maintenance.
- Establish formal international collaborations with global aviation training institutions and regulators to benchmark best practices and co-develop training modules.
- Promote faculty development programs and industry immersion to keep educators updated with the latest technologies and maintenance procedures.

- Implement policy-level reforms that support CBE adoption, cross-border certification equivalency, and sustained funding for technical education advancement.

5.1.3 Study Limitations

While this study provides meaningful insights into aviation maintenance education, certain limitations must be acknowledged. First, the participant pool was limited to a single institution (PhilSCA), which may affect the generalization of the findings to other aviation schools in the Philippines or globally. Second, although appropriate for capturing expert insights, purposive sampling may introduce selection bias. Third, curriculum alignment was assessed based on current regulatory standards, which may not fully capture emerging competencies required in future aircraft technologies. Lastly, the study's cross-sectional nature limits its ability to assess the long-term outcomes of curriculum reforms or training interventions.

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Conflict of Interest

The author declares no conflict of interest in this study's conduct, analysis, or publication.

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Authors' Contribution

Study's conceptualization and design, developed the methodology, supervised the research process, and prepared the initial manuscript draft: *Author Dela Peña;* ***Data curation and formal analysis and supported the manuscript's review and editing:*** *Meredith Rutao;* ***Investigation, validation of findings, and preparation of visual materials:*** *Harold Tiglao;* ***Coordinated fieldwork, facilitated participant recruitment, and contributed to manuscript review, editing, and final proofreading:*** *Sheena Serrano. All authors read and approved the final version of the manuscript.*

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