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Article

The influence of training, gender, and work experience on the performance of air traffic controller personnel

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Work experience duration

ABSTRACT

Limited studies have examined the combined impact of training, gender, and work experience on air traffic controllers' (ATC) performance. This study examines the simultaneous influence of training, gender, and work experience on ATC performance at AirNav Indonesia's Medan Branch, aiming to identify dominant predictors and policy implications. A quantitative associative design was employed with saturated sampling of 69 ATC personnel holding Aerodrome Controller Ratings. Data were collected via validated questionnaires (Cronbach's $\alpha > 0.7$) and standardized rating tests, then analyzed using multiple regression ($\alpha = 0.05$). The model explained 26% of performance variance ($R^2 = 0.26$, $F(3,56) = 6.572$, $p = 0.001$). Training (= 0.344, p = 0.010) and work experience (= 0.286, p = 0.031) were significant, while gender (= -0.078, p = 0.529) was insignificant. The data analysis results indicate that the simultaneous F test result's significance value is sig 0.001 <0.05, which means they have a simultaneous effect. The findings emphasize prioritizing recurrent training programs and experience-based assignments for ATC. The remaining 74% unexplained variance, particularly the minimal explained variance in the current model, highlights the need for future research to explore additional performance factors such as cognitive abilities and team dynamics, while the findings continue to support gender-neutral scheduling policies.

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Introduction

In the aviation sector, adherence to strict safety regulations is a need. All areas of transportation and air transport operations, airports, navigation, maintenance, repair, and training to adhere to the International Civil Aviation Organization (ICAO) regulations need aviation safety. Since safety in aviation is of the utmost importance, the best safety standard must be determined by consulting current aviation standards. It is related to statistical data from recent decades reveals that daily aviation accidents produce multi-dimensional impacts, with human casualties extending beyond aircraft occupants to include ground victims in urban environments (Li, Y., Zhang, Y., Wang, L., & Guan, 2022).

(Shuen, 2016), asserts that the world economy and industrialization's quick advancements have increased occupational accidents and injuries. The number of incidents brought on by machinery and equipment failure is decreasing due to technological advancements and increased dependability. On the other hand, people play a big part in workplace accidents.

Research and statistical data indicate that 80% and 90% of workplace accidents have human causes. Over time, the notion that human mistakes cause accidents has evolved. Many years ago, contact between people and machines and inadequate workplace and equipment design or operating system malfunctions were considered human factor-induced accidents (Shuen, 2016).

Air Traffic Controller, abbreviated as ATC or controller, is generally considered one of the many professions requiring a high mental load (Costa, 1996; Fathimahhayati et al, 2018). Various studies related to this profession have also been conducted (Ibrahim, S., Alzughibi M., Anuar A., Azmin B., 2021; Y. Wang, L. Wang, 2021; Rachmadina, K. M., & Puspitadewi, 2019; Rahmati & Izadpanah, 2021a). In this field of work, decisions need to be made within seconds. This requires a high mental load, such as thinking, making decisions, calculating, remembering, observing, and monitoring things quickly in a short time while working. The Air Traffic Controller (ATC) profession requires an extremely high level of knowledge and expertise, as well as the practical application of specific skills related to the cognitive domains (e.g., spatial perception, information processing, logical reasoning, decision making), aspects of communication, and human relations (Costa, 1996).

In recent years, research on accidents caused by human factors has shown a changing trend. Attention is more focused on individual factors and organizational factors that contribute to workplace accidents caused by human factors. "Safety First" is the main sign that is often found in organizations related to safety (critical safety organization). This shows that safety is paramount because it has always been a significant issue in this organization. In safety-related organizations, communication plays a vital role in terms of ensuring safety performance (Rafidah, 2014). Implementing safety activities in an organization is a challenge because it is related to the quality of communication, which can be considered one factor contributing to fatal workplace incidents The effective performance of an air traffic management (ATM) system also depends on competent and qualified air traffic management professionals (International Civil Aviation Organization, 2017). Several studies have proven that training is one factor contributing to a person's performance (Aditya, 2015; Sarwono et al & & Sarwoni, 2021). The foundation for such performance begins with rigorous training programs designed to prepare controllers for operational duties and sustain their professional competencies. (International Civil Aviation Organization, 2007) outlines that ATC training follows a competency-based framework focused on: (1) performance-oriented instruction, (2) measurable performance standards, and (3) curriculum development aligned with these standards. Such training develops controllers' ability to resolve novel, high-stakes situations - a critical skill given that they must simultaneously ensure safety and efficiency even during laboratory-based simulation exercises.

The correlation between two variables reveals a directly proportional relationship. Another research that discusses the performance, especially of air traffic controller (ATC) personnel, is by (Rahmati & Izadpanah, 2021b), who investigated the performance and proficiency of Iranian air traffic controllers simultaneously. This research reveals that performance positively and significantly affects individual proficiency. Furthermore, the influence of performance on proficiency, work experience, and completion of an aviation English course has a positive moderating role (Rahmati & Izadpanah, 2021a). According to the Law of the Republic of Indonesia Number 1 of 2019 concerning Aviation, all licensed professionals are required to perform work in accordance with the provisions of their field, maintain their abilities, and undergo regular health exams. ATC is one of the aviation personnel, licensed or certified personnel (Yazgan et al., 2021), who are given duties and responsibilities in the aviation sector. Every ATC personnel must have a license and competency certificate from a certified education and training institution.

The phases of ATC staff development include initial training, training required for control responsibilities in operational units, and training that assists competent ATCs in maintaining their competency (International Civil Aviation Organization, 2017). Moreover, three phases are typically involved in the delivery of competency-based training and assessment for ATC: "basic training," which is typically conducted once; "rating training," which is conducted once per rating; and "unit training," which is conducted once per unit, sector, or specific group of sectors.

However, the Airnav Indonesia Medan Branch, which has a total of 84 ATC personnel, has yet to accommodate all training for the development of ATC personnel (Estrova, 2023). Another factor that is thought to play a role in performance related to aviation safety is gender (Alaydi & Ng, 2024). International Civil Aviation Organization releases new data on status of global aviation gender equality on april 2023, that the participation of women holding positions as pilots, air traffic controllers, and maintenance technicians has increased on an overall basis from 4.5% globally in 2016, to 4.9% in 2021 and the number of women air traffic controllers remained stable globally at around 20.6% (International Civil Aviation Organization, 2023). However, studies on gender differences in air traffic control are minimal and have not yet reached a conclusive direction. Based on the data obtained, 50% of the total Medan Branch ATCs are women, and 85% of these female ATCs are entering the productive age period, namely aged 22 to 35 years, which is the productive age for having children (Mohite & Kumar, 2019).

Perum LPPNPI or AirNav Indonesia, the only agency providing aviation services and navigation in Indonesia, provides a policy for flight traffic control personnel regarding maternity leave for 3 (three) months (Jafari Roodbandi et al., 2025). Furthermore, after the personnel have completed their leave, they cannot work directly to provide flight traffic services as usual (Toumasis, 2023). These personnel must adapt again before carrying out their duties as an ATC, and refreshments can be given to them if necessary.

Apart from training and gender, another factor that is also thought to contribute to performance is work experience, as previously mentioned in the research of Rahmati (Rahmati & Izadpanah, 2021b). Work experience shows a person's abilities or skills in a job. Someone with work experience can do a job more quickly than someone who does not have experience (Husain, 2018). Nitisemito in (Sartika, 2022) argues that acquiring work experience enables employees to perform assigned tasks effectively. Furthermore, work experience significantly influences employee performance, as it enhances both work achievement and overall productivity. The difference in employee tenure will, of course, also affect performance. Foster establishes three fundamental indicators for assessing work experience: (1) the duration of employment, (2) the extent of acquired knowledge and skills, and (3) proficiency in operational procedures and equipment utilization (Sartika, 2022).

Airnav Indonesia was created in 2012. Previously, PT Angkasa Pura (Persero) and the Ministry of Transportation directly managed aircraft navigation system services. The work period of new employees recruited in 2012 is relatively young compared to employees who had worked from Angkasa Pura before moving to AirNav. The difference in employee tenure will, of course, also affect performance. This research tries to complement previous research by analyzing the influence of gender and other factors, such as training and work experience, on the performance of flight traffic control personnel in the Airnav Medan Branch Office and the unit offices below.

Methods

Based on the kind of data, this study falls under the category of quantitative research, which uses a positivist approach to study particular populations or samples. Typically, research tools are used for data collecting; sampling is done randomly, and statistical and quantitative testing of preconceived hypotheses is done for data analysis (Sugiyono, 2022). Moreover, it is categorized based on the depth of explanation. If so, this study falls under associative/relationship research, which is studies that try to establish a connection between two or more variables (Siregar, 2013).

Furthermore, when looking at the relationship between variables concerning the object being studied, this research is more causative, so in this research, there are independent variables (causes) and dependent variables (effects). Training variables (X1), gender (X2), and work experience (X3) are independent variables, while the performance variable of air traffic controllers (Y) is the dependent variable. The conceptual framework of the relationship between variables can be seen in the following figure 1.

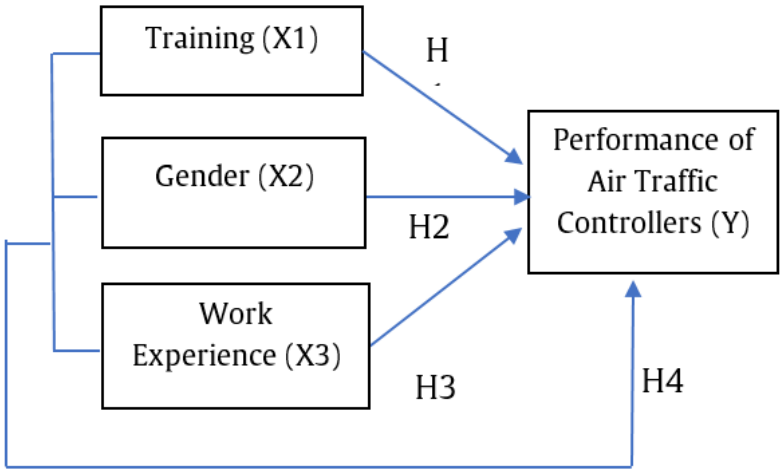

Figure 1 Conceptual Framework of Relationships Between Variables

The hypotheses or assumptions from the conceptual framework above can be formulated as follows: H1. Training is suspected to have a partial influence on the performance of air traffic controllers; H2. Gender is suspected to have a partial influence on the performance of air traffic controllers; H3. Work experience is suspected to have a partial influence on the performance of air traffic controllers; H4. Training, gender, and work experience are suspected to have a joint influence on the performance of air traffic controllers.

Method of collecting data

The location of this research is the AirNav Indonesia's Medan Branch, which oversees one sub-branch office (Gunung Sitoli) and three unit offices (Silangit, Sibolga, and Aek Godang). The air traffic guidance services at the Medan branch include aerodrome control service, approach control surveillance service, and terminal area control surveillance service. Meanwhile, the Gunung Sitoli sub-branch office and the Silangit unit only provide aerodrome control service for air traffic guidance. An aerodrome information service is provided for the Sibolga and Aek Godang office units (International Civil Aviation Organization, 2022). In this study, the population and sample were taken only from the air traffic control personnel with the rating/authority to provide aerodrome control service. Therefore, the specified personnel locations are the Medan Branch, Gunung Sitoli Sub-branch, and Silangit Unit.

This study was conducted from March to October 2022. Sampling was carried out using a saturated sampling technique, which means that all population members were used as samples to obtain generalizations with a tiny margin of error (Sugiyono, 2022). All samples were considered to meet the requirements with the criteria of air traffic controllers who have an Aerodrome Controller Rating (TWR). Data collection instruments were distributed to 69 respondents, but only 60 completed the questionnaire.

Next, in terms of data collection, the three dependent variables, namely training (X1), gender (X2), and work experience (X3), are measured using a data collection instrument in the form of a questionnaire with a Likert scale, ranging from 1 to 5. Meanwhile, the independent variable, performance (Y), is measured using a secondary data instrument consisting of exam score records.

The statement of items on the training variable questionnaire is based on the theory that the training process utilizes systematic and organized procedures where non-managerial employees learn knowledge and technical skills for specific goals Andrew E. Sikula (Mangkunegara A.A, 2017). Based on this theory, statements related to the indicators of training goals and objectives, trainers, training materials, training methods, and training participants are formulated. The item statements on the Gender variable questionnaire are based on the theory that gender represents different categories (Mcmillan-capehart, 2003). From this theory, statements related to indicators of prosocial and antisocial behavior, group behavior, and non-verbal behavior were developed. The item

statements on the work experience variable questionnaire are based on the theory that a person can be said to have work experience if they meet several indicators such as the duration/time of work, the level of knowledge and skills possessed, as well as mastery of the job and equipment Foster (Sartika, 2022). Meanwhile, the instrument to measure the performance variable of air traffic controllers is secondary data in the form of recorded data from the aerodrome control tower evaluation tests for the second semester of 2022 conducted by the certified ATC Checker from AirNav Medan Branch.

Data Analysis Method

This research is an examination to test associative hypotheses using correlation techniques. The correlation technique is used to determine the degree or strength of the relationship between three or more independent variables and a dependent variable, as well as to determine the contribution provided collectively by the independent variables to the value of the dependent variable and the partial contribution provided by each independent variable to the dependent variable (Siregar, 2013). Additionally, the acquired data was subjected to multiple linear regression analysis after being subjected to validity and reliability tests to assess data quality, as well as tests of data normality (Kolmogorov-Smirnov test), multicollinearity, and heteroscedasticity to assess classical assumptions (Herasymenko et al., 2021).

Results and Discussion

Data Quality Test

The training variable's (X1) data validity test results with a total of 20 (twenty) questionnaires, For the gender instrument (X2), a total of 15 (fifteen) questionnaire, and for the work experience instrument (X3), a total of 12 (twelve) questionnaires were obtained using statistical applications(Roberts, 2021), namely that all questionnaires were declared valid. The reliability test results on the training, gender and work experience variables were that all questionnaires were declared reliable (Puyod & Charoensukmongkol, 2019). The processed data can be explained on the tables.

Table 1. Validity Test of the Training Variable Questionnaire (X1)

No Item	r hitung count r	r tabel 5 % table r 5 %	Keterangan Explanation
1	0.342	0.2542	Valid
2	0.594	0.2542	Valid
3	0.694	0.2542	Valid
4	0.654	0.2542	Valid
5	0.729	0.2542	Valid
6	0.627	0.2542	Valid
7	0.657	0.2542	Valid
8	0.826	0.2542	Valid
9	0.823	0.2542	Valid
10	0.789	0.2542	Valid
11	0.438	0.2542	Valid
12	0.666	0.2542	Valid
13	0.739	0.2542	Valid
14	0.687	0.2542	Valid
15	0.588	0.2542	Valid
16	0.731	0.2542	Valid
17	0.678	0.2542	Valid
18	0.660	0.2542	Valid
19	0.595	0.2542	Valid
20	0.640	0.2542	Valid

The basis for decision-making is comparing the calculated r with the table r. If the calculated r > table r, it is declared valid. The value of the table r for data N=60 at a significance level of 5% is 0.2542. Looking at the data in the Corrected item-Total Correlation column in table 1, the calculated r > table r declares that 20 questionnaire items are valid.

Table 2. Validity Test of Gender Variable Questionnaire (X2)

No Item	r hitung count r	r tabel 5 % table r 5 %	Keterangan Explanation
1	0.514	0.2542	Valid
2	0.531	0.2542	Valid
3	0.556	0.2542	Valid
4	0.670	0.2542	Valid
5	0.555	0.2542	Valid
6	0.524	0.2542	Valid
7	0.703	0.2542	Valid
8	0.430	0.2542	Valid
9	0.302	0.2542	Valid
10	0.441	0.2542	Valid
11	0.435	0.2542	Valid
12	0.517	0.2542	Valid
13	0.788	0.2542	Valid
14	0.580	0.2542	Valid
15	0.565	0.2542	Valid

Looking at the data in the Corrected item-Total Correlation column in Table 2, the calculated r is greater than the table r, thus stating that 15 questionnaire items are valid.

Table 3. Validity Test of the Work Experience Variable Questionnaire (X3)

No Item	r hitung count r	r tabel 5 % table r 5 %	Keterangan Explanation
1	0.579	0.2542	Valid
2	0.528	0.2542	Valid
3	0.532	0.2542	Valid
4	0.547	0.2542	Valid
5	0.590	0.2542	Valid
6	0.491	0.2542	Valid
7	0.617	0.2542	Valid
8	0.640	0.2542	Valid
9	0.685	0.2542	Valid
10	0.734	0.2542	Valid
11	0.453	0.2542	Valid
12	0.636	0.2542	Valid

Looking at the data in the Corrected item-Total Correlation column in Table 3, the calculated r is greater than the table r, thus stating that 12 questionnaire items are valid. Meanwhile, the results of the Cronbach's Alpha reliability test for this study's three independent variable instruments are reliable. The Alpha value can be interpreted as follows: 1) Alpha value >= 0.90 "Very Good"; 2) Alpha value > 0.70 "Good"; and 3) Alpha value < 0.70 "Not Good". The processed data can be seen below:

Table 4. Results of Reliability Testing for the Training Instrument (X1)

Cronbach's Alpha	N of Items
.759	21

The Cronbach's Alpha value of instrument X1 is 0.759, which can be interpreted as 'Good.'

Table 5. Results of Gender Instrument Reliability Test (X2)

Cronbach's Alpha	N of Items
.746	16

The Cronbach's Alpha value of instrument X2 is 0.746, which can be interpreted as 'Good.'

Table 6. Results of Reliability Testing for the Work Experince Instrument (X3)

Cronbach's Alpha	N of Items
.752	13

The Cronbach's Alpha value of instrument X3 is 0.752, which can be interpreted as 'Good.'

Normality test

Before testing the hypothesis, it is necessary to carry out a normality test first. This test aims to determine whether or not the data is regularly distributed (Mahmood et al., 2023).

Table 7. Results of Normality Test for Variable Y

One-Sample Kolmogorov-Smirnov Test		
		Unstandardized Residual
N		60
Normal Parametersa,b	Mean	.0000000
	Std. Deviation	5.15442154
Most Extreme Differences	Absolute	.071
	Positive	.046
	Negative	-.071
Test Statistic		.071
Asymp. Sig. (2-tailed)		.200c,d

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.
d. This is a lower bound of the true significance.

Table 7 shows the significance value of 0.200 > 0.05, so all data is typically distributed.

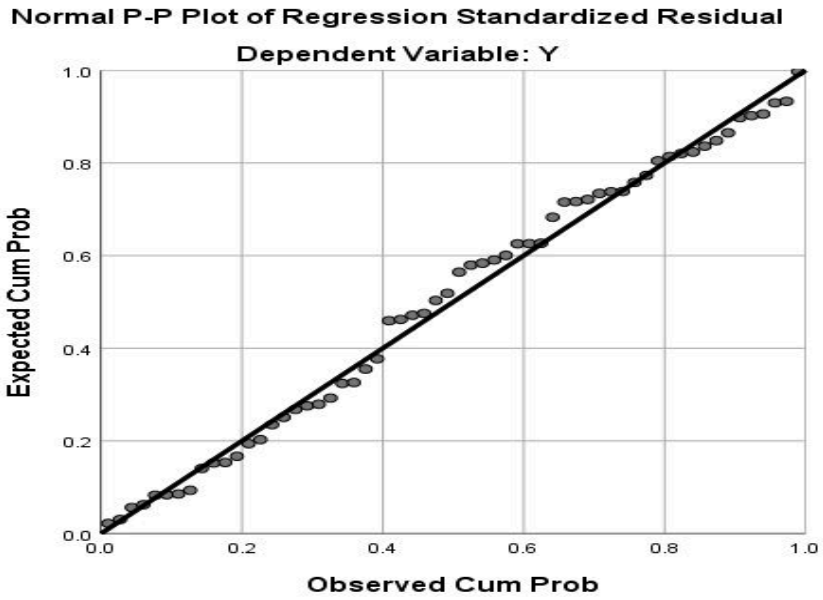

Figure 2 Diagonal Line Figure Test of Normality for Dependent Variable Y

Multicollinearity Test

The multicollinearity test (Table 8) reveals that no independent variables have a tolerance value ≤ 0.10, indicating no correlation between independent (free) variables with values greater than 95% (Wong et al., 2023). The VIF calculation results demonstrate that no independent variable has a VIF value of > 10. As a result, this regression model's independent (free) variables have no sign of multicollinearity (Lin et al., 2025).

Table 8. Multicollinearity Test and Multiple Linear Regression

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	48.172	9.102		5.293	.000					
	X1	.275	.104	.344	2.650	.010	.441	.334	.305	.786	1.272
	X2	-.068	.107	-.078	-.633	.529	.107	-.084	-.073	.879	1.138
	X3	.334	.151	.286	2.219	.031	.409	.284	.255	.794	1.260

a. Dependent Variable: Y

Hypothesis testing

After the two tests above have been carried out, the hypothesis test is then carried out, in this case, using the product-moment correlation technique (Sholihah, 2019). This technique is used to determine whether there is an influence between variables. Then, multiple linear regression tests were performed to test this study's hypothesis on whether there is an influence of the independent variable on the dependent variable.

The results of the data processing in Table 8 showed that the training variable (X1), gender (X2), and work experience (X3) have a partial effect on the performance of air traffic controllers (Y), both individually and collectively affecting variable Y. Furthermore, based on Table 8, the multiple linear regression equation can be constructed as follows: Y = a + $b1X1$ + $b2X2$ + $b3X3$. + bnXn ... (1)

a, b1, and bn are constants, while X1, X2, X3, and Xn are independent variables, and Y is the dependent variable. From Table 8, the multiple linear equations can be formulated as follows: Y = 48.712 + 0.275 X1 - 0.68 X2 + 0.334 X3 ... (2)

From equation (2) it can be explained as follows: (1) The constant value of 48.712 indicates a positive sign, meaning that if the variables Training, Gender, and Work Experience are zero, then the variable Performance of air traffic controllers increases by 48.712 units; (2) The value of the regression coefficient for the Training variable (X1) is 0.280, which means that every change in the X1 variable of one unit will increase the performance of air traffic controllers by 0.275 units. Conversely, decreasing one unit in the training variable will decrease performance by 0.275, assuming other variables remain constant; (3) The regression coefficient value on the gender variable of -0.68 indicates a negative influence (opposite direction). If the Gender variable increases by 1 (one) unit, the performance of air traffic controllers will decrease by 0.68, assuming that other variables remain constant; (4) The regression coefficient value for the work experience variable shows a positive value of 0.334, indicating that if work experience increases by 1 (one) unit, the performance of air traffic controllers will increase by 0.334, assuming other variables remain constant.

Next, the significance of the partial influence between variables can be seen through the t-test. A relationship will be meaningful in this test if the calculated t value > table t value. Using a confidence level of 95% (=0.05 and degrees of freedom (df)=(n-k-1) (Hussain et al., 2018), the t table value is

2.003 (Malekzadeh et al., 2019). Partial t-test decision-making can be based on the significant value, specifically, if the dependent variable (Y) has some influence by the independent variable (X) with Sig. < 0.05 (Table 8)(Oppong & Zhou, 2021)., the table t value obtained is 2.003. Table 8 shows that the calculated t-value for variable X1 is 2.650 > 2.003, which means it has a positive influence. Variable X2 has a calculated t value of -0.663 < 2.003, which means it has a negative influence. Variable X3 has a calculated t value of 2.219 > 2.003, which means it has a positive influence. Meanwhile, the calculated t values for X1, X2, and X3 together are 5.293 > 2.003, which means that they have a positive influence on variable Y.

The F test also obtained the same result by comparing the F calculated value with the F table. Decision-making for the F Test (Multiple Linear Regression) is based on the calculated and table values. The simultaneous influence of training, gender, and job experience on performance has a sig value of 0.001 < 0.05, as indicated by the significance of the F Test findings (simultaneous)(Chicco et al., 2021). Comparing the Fcount and Ftable numbers yielded the same findings (Table 9), with Fcount 6.572 > Ftable 2.77.

Therefore, it is fair to assert that "training has a positive effect on performance (hypothesis H1)" (Wang et al., 2019) and "work experience has an effect on performance (hypothesis H3)". Conversely, it is unacceptable to claim that "gender has a positive effect on performance (hypothesis H2)"(Riyanto et al., 2021).

Table 9. The Influence of Variable X Simultaneously on Variable Y

ANOVAa

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	551.844	3	183.948	6.572	.001b
	Residual	1567.516	56	27.991		
	Total	2119.359	59			

a. Dependent Variable: Y
b. Predictors: (Constant), X3, X2, X1

The influence of the three variables (training, gender, and work experience) simultaneously on performance is 26% (Wang et al., 2019). This can be seen in the Model Summary table, which has an R Square value of 0.260. This means that all Y changes are caused by X of 26% (Table 10) (Chicco et al., 2021).

Table 10. F Test Results

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.510[a]	.260	.221	5.29069	.260	6.572	3	56	.001

a. Predictors: (Constant), X3, X2, X1
b. Dependent Variable: Y

Conclusion

Training and work experience factors influence the performance of aviation traffic control personnel, so there will be equal and sustainable opportunities for ATC personnel in training, especially refresh training, which is carried out several times to maintain their competence. In different situations,

additional training may be needed, such as training for system updates or training following a lengthy absence from an operational role (leave).

Regarding gender, this has not been proven to influence personnel performance, so work scheduling (work shifts) does not differentiate between genders. Furthermore, other researchers can also conduct similar research by first determining specific criteria before collecting data on performance variables. This research can also be developed by examining other factors that contribute more to the performance of air traffic controllers. It might be to explore additional performance factors such as cognitive abilities and team dynamics, while the findings continue to support gender-neutral scheduling policies.

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