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Gender, Region, and Field of Expertise in Vocational Education: A Map of Inequality among Vocational High School Students

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ABSTRACT

This study maps and analyzes inequalities in vocational field of expertise choices among Indonesian vocational school students by gender and region. The research employed descriptive quantitative methods, including the Chi-square Test, Analysis of Variance (ANOVA), Heatmaps, Decision Tree Classifiers, Lasso Regression, and Quartiles. The research data were vocational school data in 39 regions and vocational school students in 2023. Gender differences influenced the choice of area of expertise in vocational schools. There were areas of expertise in the male domain or the female domain. The region categorization did not influence the number of male and female students or the choice of field of expertise. These results were due to a gendered distribution across vocational fields arising from social norms and peer-composition signals rather than from a regional inequality context. This research is poised to significantly influence policies that promote equitable gender representation among students in vocational fields at vocational schools.

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1. INTRODUCTION

The establishment of vocational schools aimed to develop skilled graduates who could meet labor market demands (Rosina *et al*., 2021). Along with this purpose, research on vocational education has expanded significantly, reflecting its central role in preparing human resources (**Table 1**). Among the key issues that consistently emerge in this field are gender, region, and field of expertise, since these factors shape access, participation, and outcomes in vocational education.

In Indonesia, vocational high schools were expanded to address labor market needs, reinforced by the government policy in 2008 that set a 70:30 ratio between vocational and general education. This policy underscored the strategic role of vocational schools in producing a skilled workforce that could strengthen national competitiveness. Empirical studies have credited vocational education with reducing unemployment both in Indonesia and in international contexts, although the evidence is mixed and sometimes contradictory (Yoana & Rumayya, 2024; Acevedo *et al*., 2020; Ariansyah *et al*., 2024). On one hand, vocational education has opened pathways to employment for many; on the other hand, some findings suggest that vocational schools have not consistently fulfilled this role.

Despite these efforts, gender inequality remains a persistent concern (Francis *et al*., 2023; Demalata *et al*., 2024; Fiandini *et al*., 2025; Boriongan & Abdulmalic, 2023; Pranathi & Kamraju, 2024; Demalata *et al*., 2024; Bolaji *et al*., 2025; Situngkir *et al*., 2024; Fagbemi, 2023; Bhatta, 2016; Choi, 2020; Du *et al*., 2025; Fauziah *et al*., 2022; Heiniger & Imdorf, 2018). Females are often disadvantaged in fields requiring digital technology skills, which limits their opportunities in emerging labor markets. This gap persists even though evidence shows that females generally demonstrate higher academic achievement and greater persistence in education compared to males (Astuti, 2023; Lovat & Darmawan, 2019).

These contrasting realities illustrate how vocational schools simultaneously provide opportunities while also reproducing inequalities. As a result, vocational education stands at a critical intersection between access and exclusion, highlighting the importance of examining gender, regional disparities, and field of expertise choices as interconnected dimensions of inequality (Han *et al*., 2023).

Research has shown that vocational training environments remain influenced by gender norms. Female students are concentrated in fields such as business, management, health, and social work, while male students dominate engineering, maritime, and technical domains (Van der Meulen Rodgers & Boyer, 2006; Ray & Zarestky, 2022). These patterns reflect long-standing divisions in vocational education, dating back to colonial times when male and female expertise tracks were explicitly separated (Pambudi & Harjanto, 2020). Although vocational schools have since diversified into numerous expertise areas, segregation persists, reinforced by social perceptions, peer influence, and job expectations after graduation (Lappalainen *et al*., 2013; Porter & Serra, 2020).

International studies similarly confirm that vocational education tends to reproduce gendered career pathways, with implications for employment equity (Tao *et al*., 2022; Du *et al*., 2025). While gender differences have been widely studied, the role of regional variation remains less explored. Regional development policies aimed to expand vocational schools outside Java, yet disparities in institutional distribution and industrial concentration persist (Mardianto *et al*., 2019; Sujono, 2023). Previous findings suggest that geographical contexts may influence access and female participation in technical fields, though evidence in Indonesia remains limited (Han *et al*., 2023).

This study addresses these gaps by mapping vocational school participation across gender and region using recent national data. The novelty lies in combining statistical analysis and machine learning models to test whether vocational expertise choices are determined more by gender or regional differences. The impact of this research is to provide empirical insights that can inform equitable policies, ensuring that vocational education promotes inclusive opportunities rather than reinforcing gendered divisions in the labor market.

Table 1. Previous studies on vocational school and education.

No	Title	Reference
1	Green skills understanding of agricultural vocational school teachers around West Java Indonesia	Handayani *et al*. (2020)
2	Trends in expert system development: A practicum content analysis in vocational education for over grow pandemic learning problems	Ana (2020)
3	Distance learning in vocational high schools during the covid-19 pandemic in West Java province, Indonesia	Mulyanti *et al*. (2020)
4	An instructional design for online learning in vocational education according to a self-regulated learning framework for problem solving during the covid-19 crisis	Sangsawang (2020)
5	Competency index of technical vocational education and training (TVET) instructors for 4.0 industrial revolution	Shahroni *et al*. (2022)
6	The urgency of online learning media during the Covid-19 pandemic at the vocational school in Indonesia	Huwaidi *et al*. (2021)
7	Ergo design of mentoring in the national ecosystem of vocational education in the period of the 10th technological order	Glushchenko (2022)
8	Sustainable global economy through technical and vocational education and training for skilled workforce in achieving good governance	Olabiyi (2025)
9	Teaching of the production and acceptance analysis of instant urap seasoning in the vocational school	Rahmadhani *et al*. (2021)
10	Portfolio-based assessment in research methodology course students in vocational education	Nurhayati *et al*. (2024)
11	Measurement of the level of digital competence of vocational teachers in learning development	Massadah and Widaningsih (2024)
12	Curriculum development in science education in vocational school	Maryanti and Nandiyanto (2021)
13	Barriers limiting the use of google classroom for learning vocational and entrepreneurship courses	Joshua *et al*. (2022)
14	A bibliometric analysis of vocational school keywords using VOSviewer	Al Husaeni and Nandiyanto (2023)
15	Current issue in the technical vocational education and training (TVET) instructor	Minghat *et al*. (2023)
16	Interactive multimedia design of motion graphics using a project-based learning approach for vocational education students: Experiments in cooking taliwang chicken	Nurani *et al*. (2024)
17	The relationship of vocational education skills in agribusiness processing agricultural products in achieving sustainable development goals (SDGs)	Gemil *et al*. (2024)
18	Understanding vocational students' perception of video animation "physical activity and dietary behavior"	Muktiarni *et al*. (2024)
19	Methodology for investigating competency index of technical vocational education and training (TVET) instructors for 4.0 industrial revolution	Shahroni *et al*. (2022)
20	Literature review: Technical and vocational education and training (TVET) in Malaysia	Minghat *et al*. (2022)

Table 1(Continue). Previous studies on vocational school and education.

No	Title	Reference
21	How to make a cognitive assessment instrument in the merdeka curriculum for vocational high school students: A case study of generating device materials about the stirling engine	Fiandini *et al.* (2024)
22	Industrial engineering students' readiness towards industrial revolution 4.0 at technical and vocational university: Literature review	Anwar and Minghat (2024)
23	Adaptive strategies for technical and vocational education and training (TVET) science educators: Navigating online home-based learning	Hashim *et al.* (2024)
24	Bibliometric analysis on artificial intelligence research in Indonesia vocational education	Rahmiyanti (2024)
25	Experimental Demonstration for Teaching the Concept of Steam Engine Power Plant to Vocational Students to Support the Sustainability Development Goals (SDGS) and its Comparison to Indonesian Merdeka Curriculum	Fiandini *et al.* (2024)
26	Bibliometric analysis of engineering research using vosviewer indexed by Google Scholar	Nandiyanto and Al Husaeni (2022)
27	A bibliometric analysis of chemical engineering research using vosviewer and its correlation with covid-19 pandemic condition	Nandiyanto *et al.* (2021)
28	A computational bibliometric analysis of science education research using VOSviewer	Maryanti *et al.* (2023)
29	Sustainable development goals (SDGs) in science education: Definition, literature review, and bibliometric analysis	Maryanti *et al.* (2022)

2. METHODS

The research used a quantitative approach with statistical analysis and machine learning to identify patterns of selection of areas of expertise based on gender and region. Detailed information regarding this method is explained elsewhere (Susilawati *et al*., 2025). The research data were vocational school data in 39 regions and vocational school students in 2023 (Ministry of Education, Culture, Research and Technology, 2024).

There were ten areas of expertise, namely: (i) construction technology and property, (ii) manufacturing and engineering technology, (iii) energy and mining, (iv) information technology, (v) health and social work, (vi) agribusiness and agrotechnology, (vii) maritime, (viii) business and management, (ix) tourist, and (x) arts and creative economy. Regions are 38 provinces and overseas 2023 Ministry of Education, Culture, Research and Technology, 2024). The research question was stated in the hypothesis:

(i) H01: Gender differences do not influence the choice of competency areas in vocational schools
(ii) H02: Vocational school region does not affect the number of male and female students
(iii) H03: Vocational school region does not influence the choice of field of expertise

To address these hypotheses, data were processed in several stages:

(i) The distribution of fields of expertise was calculated by gender and province.
(ii) Descriptive statistics, including mean, median, and standard deviation, were applied to examine gender dominance in each field.
(iii) The relationship between gender and expertise choice, as well as the effect of region on student composition, was tested using the Chi-square statistic, which is suitable for testing categorical data distributions.
(iv) Heatmaps were generated using Python libraries such as Seaborn, pandas, scipy, and NumPy to visualize gender-based distributions, which allowed clear interpretation of variations across provinces (Lavanya *et al*., 2023; Sial *et al*., 2021).

(v) A Decision Tree Classifier was employed to determine the most influential variables in expertise choices, with gender as the root node and the field of expertise as the terminal node. The model was built using the Gini Impurity criterion in Scikit-learn, which is effective for handling categorical data (Yang, 2021).

(vi) Logistic regression with L1 regularization (Lasso Regression) was applied to validate the decision tree results and manage high-dimensional data, ensuring reliable variable selection (El Guide *et al*., 2022).

(vii) A chi-square test was repeated to examine the effect of region on gender composition, followed by an Analysis of Variance (ANOVA) to test regional differences in expertise choice. The ANOVA method is appropriate for comparing differences across multiple groups (Abebe, 2019).

(viii) Quartile analysis was used to classify provinces into male-dominant, female-dominant, and balanced groups. The quartiles and interquartile ranges were calculated by sorting gender distribution data and identifying thresholds for group categorization, which revealed gender gaps in provincial student populations. Through these combined methods, the study systematically tested the relative influence of gender and regional factors on vocational expertise choices in Indonesia.

Finally, we analyzed statistics to get a better understanding of the results using SPSS. Detailed information on how to analyze using statistical analysis is reported elsewhere (Fiandini *et al*., 2024; Rahayu *et al*., 2024; Afifah et al., 2022).

3. RESULTS AND DISCUSSION

3.1. Distribution of Vocational Schools and Vocational School Students in Indonesia

Figure 1 shows the distribution of male and female students in vocational high schools across Indonesian provinces. The data indicate that Java Island, especially West Java, accommodates the highest number of students, while Papua Mountains has the lowest. Moreover, Jakarta records the highest proportion of female students, whereas Papua Mountains has the lowest. This unequal distribution highlights the concentration of vocational institutions in more developed regions, particularly Java, which has long been the center of industrial and economic activity (Mardianto *et al*., 2019; Sujono, 2023). In contrast, provinces outside Java, especially in Eastern Indonesia, show limited vocational school participation.

This reflects findings in other developing countries, where vocational education opportunities tend to cluster in regions with stronger infrastructure and economic support (Han *et al*., 2023). The gender composition also illustrates regional contrasts. In provinces such as Jakarta, urban settings and greater gender awareness appear to encourage more balanced participation of males and females.

Meanwhile, in remote provinces, traditional norms may still restrict females' access to vocational education, which contributes to the observed gender gap. Such findings confirm that although vocational schools were designed to expand equal access, disparities in distribution remain a significant barrier.

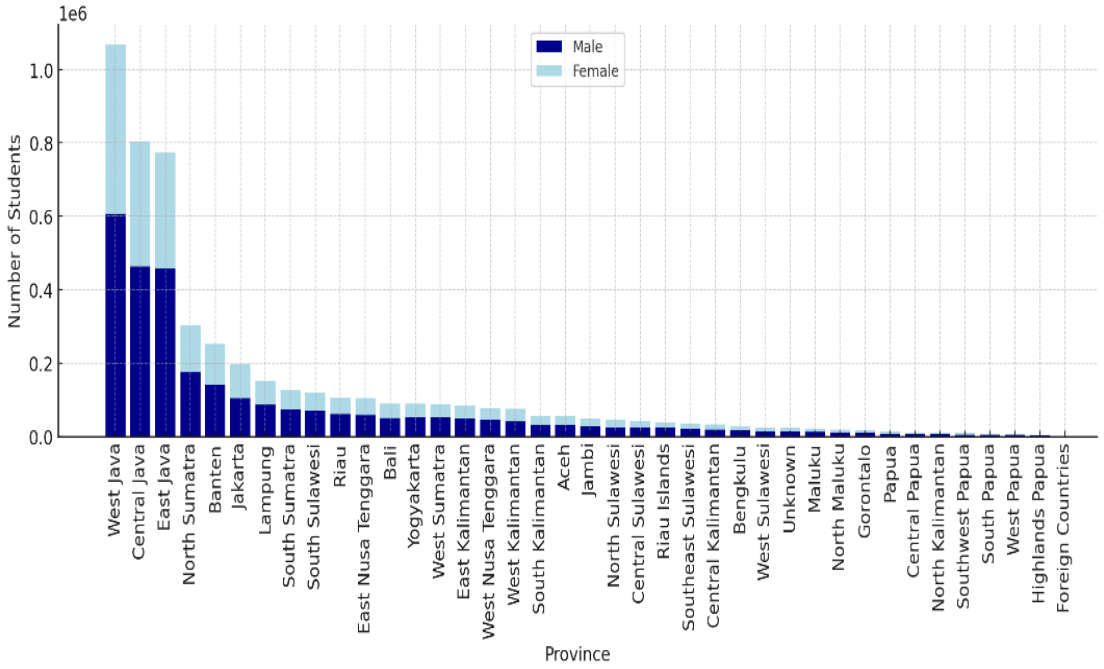

Figure 1. Number of male and female vocational school students by province.

3.2 The Influence of Gender on the Choice of Vocational School Expertise

Figure 2 presents the percentage of male and female students based on their chosen fields of expertise. The results show a clear gendered pattern: males dominate in engineering and maritime-related fields, while females are more concentrated in business, management, tourism, arts, and health-related expertise. This finding is consistent with previous studies that found gender segregation in vocational education persists across many countries, with males concentrated in technical and industrial domains and females in social and service-oriented fields (Van der Meulen Rodgers & Boyer, 2006; Ray & Zarestky, 2022; Newhouse & Suryadarma, 2011).

Further analysis using the Chi-square test confirmed that gender significantly influences expertise choice, indicating that field selection is not random but systematically shaped by gender differences. This reinforces the view that vocational education continues to reproduce traditional gender roles. For example, technical fields are often perceived as "masculine," creating barriers for females to participate, while "feminine" domains such as business and tourism remain undervalued in terms of income and status (Porter & Serra, 2020; Meri Crespo *et al*., 2024).

Figure 3 illustrates the results of the Decision Tree Classifier, where gender emerges as the root node in predicting students' choice of expertise. This means gender is the most dominant factor, surpassing other possible predictors such as region. Logistic regression with L1 regularization further validated this result, confirming that gender strongly determines the probability of choosing a particular field. Such findings echo international evidence that gender differences in vocational interests are universal, although their magnitude may vary depending on cultural contexts (Tao *et al*., 2022; Du *et al*., 2025).

The implications are critical for equity in education. While vocational schools provide pathways to employment, the strong influence of gender on field selection means that students' opportunities are shaped less by individual preferences and more by social expectations.

This gendered distribution not only channels males and females into different labor market trajectories but also perpetuates income inequality, since male-dominated technical fields often lead to higher-paying jobs (Han *et al*., 2023). Therefore, addressing gender segregation in expertise choices requires policy interventions that challenge stereotypes and promote equal access to all fields.

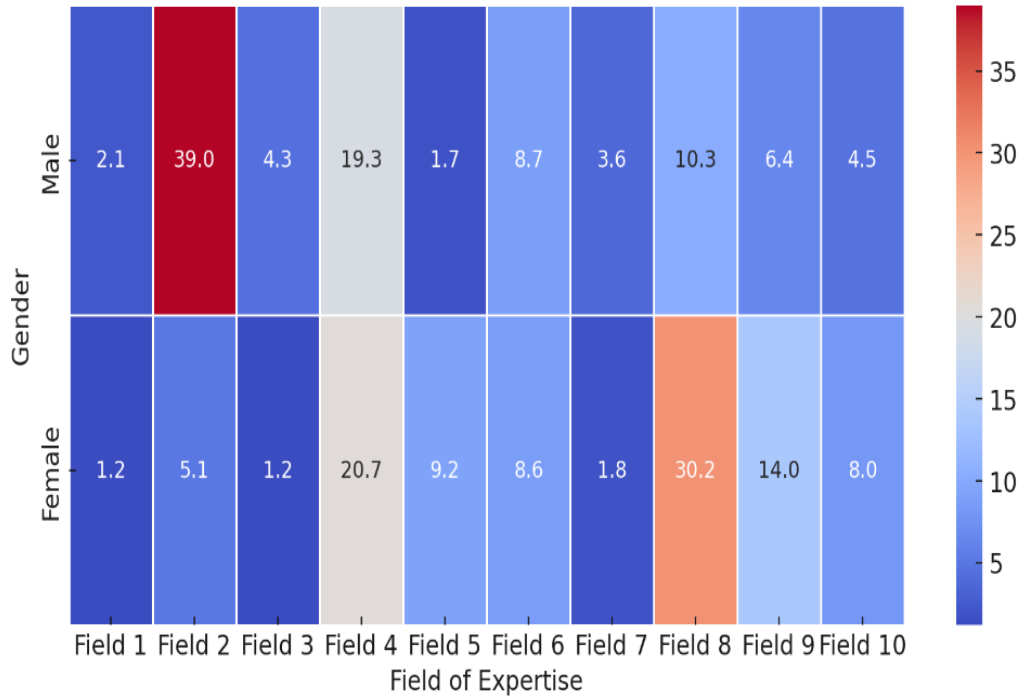

Figure 2. Percentage of male and female students based on the field of expertise.

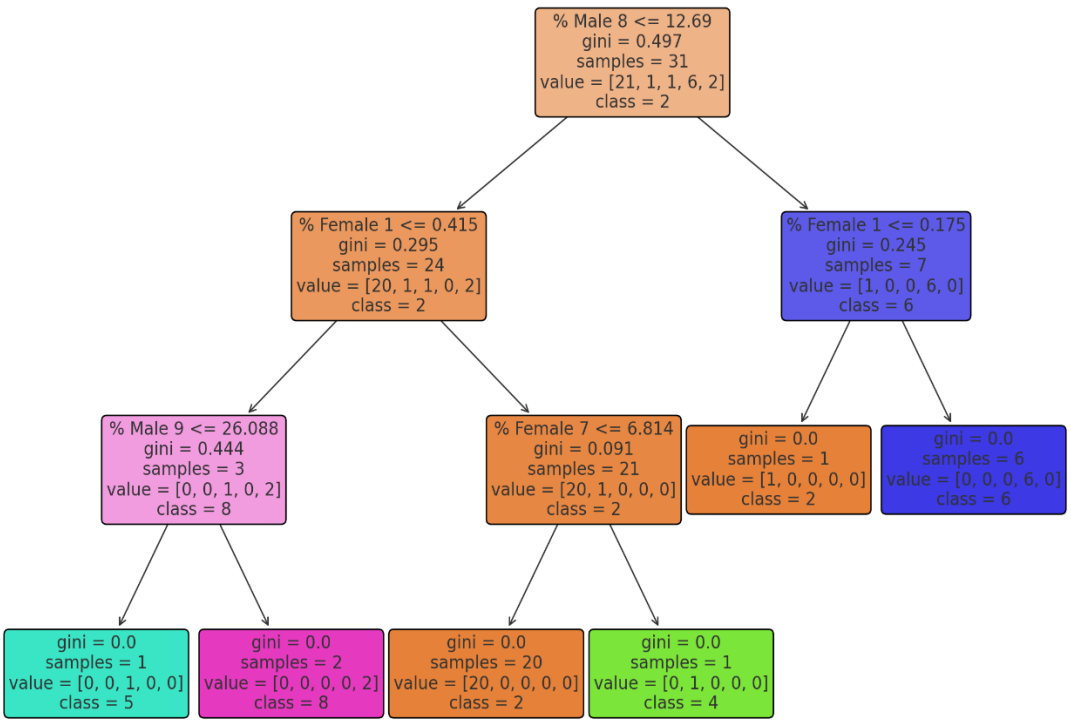

Figure 3. Decision tree of male and female students' choices regarding areas of expertise.

3.3. The Influence of Region on the Choice of Field of Expertise

Figure 4 illustrates the gender gap across provinces in Indonesia. The data show that while some provinces display relatively balanced participation between male and female students, others exhibit strong gender disparities.

Provinces such as Jakarta, Aceh, and Lampung demonstrate more balanced gender compositions, whereas provinces in Java and several outer islands show male dominance. Conversely, in some provinces like North Kalimantan and West Sulawesi, females are more represented in vocational education.

Statistical analysis using Chi-square and ANOVA tests revealed that regional variation does not significantly affect the distribution of male and female students across fields of expertise. This suggests that gender composition and field choices are less influenced by geography than by social and cultural expectations. In other words, the type of expertise selected by students tends to follow gender norms rather than regional context.

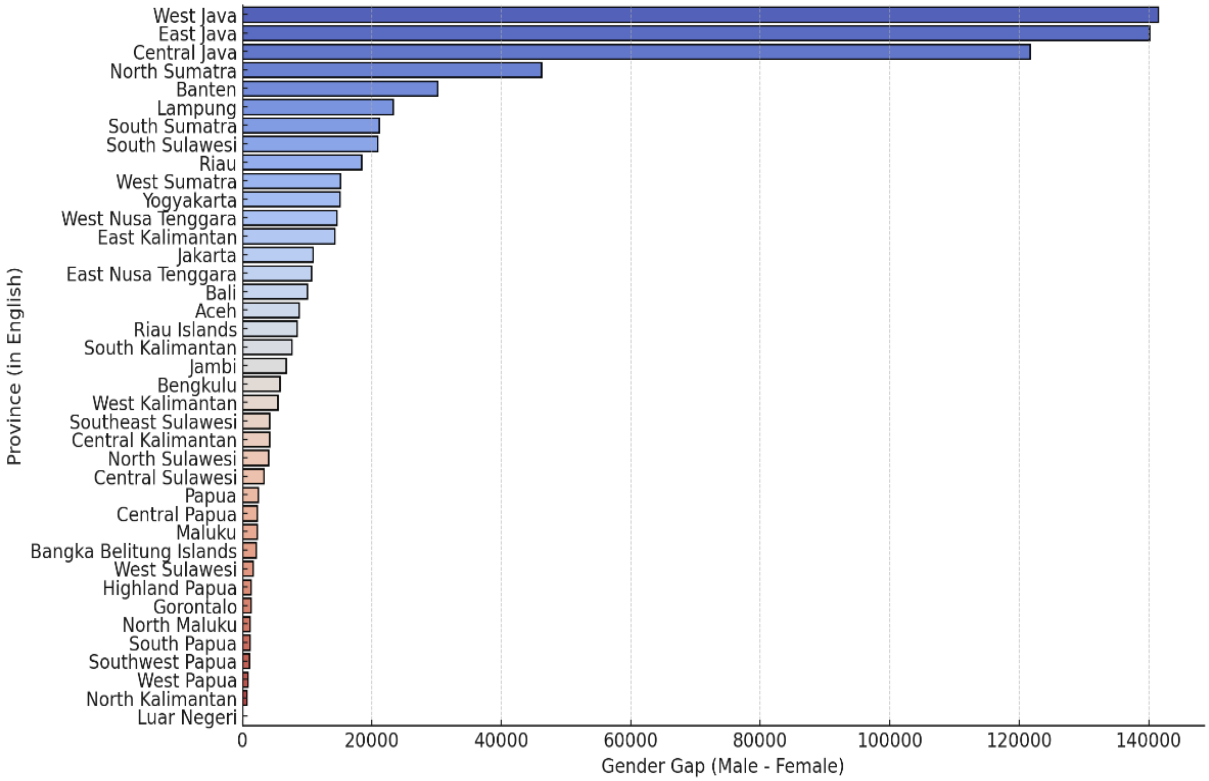

Figure 4. Gender gap between provinces

These results align with earlier findings that gender-based patterns in vocational education are deeply embedded in social structures and are reproduced across regions regardless of local differences (Khabibah *et al*., 2025).

Nevertheless, the concentration of vocational schools in Java compared to other regions indicates that institutional availability remains regionally unequal (Mardianto *et al*., 2019; Sujono, 2023). Such unequal distribution indirectly influences participation, as provinces with fewer schools provide limited opportunities for students, particularly females, to access vocational education.

International studies similarly highlight that in developing countries, access to vocational education is strongly shaped by the density of institutions and regional development levels (Han *et al*., 2023).

The evidence suggests that although regional policies aim to expand access to vocational education, their impact on reducing gender disparities remains limited. The gender gap persists primarily because cultural norms and societal expectations continue to dictate expertise preferences, overshadowing the influence of geography. Thus, while regions with higher development levels may provide more opportunities for vocational training, this does not automatically translate into gender equality in expertise choice.

3.4 Gender, Region, and Field of Expertise in Vocational Education

The combined findings presented in **Figures 1–4** highlight the intersection of gender, region, and field of expertise in vocational education. The overall pattern demonstrates that gender is the dominant factor influencing field selection, while regional variation plays a weaker and more indirect role.

As shown earlier in **Figure 2** and **Figure 3**, males are concentrated in technical and industrial domains such as engineering, manufacturing, and maritime, while females dominate in business, tourism, arts, and health-related expertise. This gendered segregation is reinforced by social norms and cultural expectations, which continue to influence vocational trajectories (Ray & Zarestky, 2022; Porter & Serra, 2020; Lamamra, 2017; Purnomo, 2021a; Purnomo, 2021b, Purnomo, 2022; Purnomo, 2023a, Purnomo, 2023b).

At the same time, **Figure 1** and **Figure 4** show that regional distribution affects the availability of institutions, with provinces in Java accommodating the majority of vocational schools and students. Although regional differences in expertise choice were not statistically significant, regions with fewer schools indirectly limit opportunities, especially for females, thereby reinforcing gender inequality (Han *et al*., 2023; Wijanarko *et al*., 2022).

In this way, the role of geography is not about altering gendered preferences but about constraining or enabling access. These findings suggest that efforts to expand vocational education must integrate both gender-sensitive strategies and regional development policies. Increasing the number of vocational institutions alone will not reduce gender segregation, as patterns of field selection are deeply embedded in social norms.

Without interventions to address stereotypes, vocational education risks perpetuating unequal labor market outcomes, where male-dominated fields typically lead to higher-paying jobs while female-dominated fields remain undervalued (Van der Meulen Rodgers & Boyer, 2006; Tao *et al*., 2022; Sugiartiningsih *et al*., 2019).

The integration of gender, region, and expertise patterns shows that vocational education continues to mirror existing inequalities. To transform vocational schools into instruments of equity, policies must explicitly promote female participation in technical domains and ensure that regional expansion is accompanied by inclusive and gender-responsive practices.

4. CONCLUSION

This study concludes that gender is the most influential factor shaping vocational high school students' choice of expertise, while regional variation plays only an indirect role through institutional availability. Male students dominate technical and industrial fields, whereas females are concentrated in business, tourism, health, and arts, reflecting persistent gendered norms.

Although the government has expanded vocational schools, regional development has not eliminated these disparities.

The novelty of this research lies in its integration of statistical and machine learning approaches with national administrative data, producing a comprehensive map of inequality. Policies must therefore prioritize gender-responsive strategies and ensure that regional expansion is accompanied by inclusive practices to make vocational education an instrument of equity rather than inequality.

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6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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