

Analysis of the Alignment Between Vocational High School Graduates Competencies and Industry Needs Using a Data Mining Approach

*Candra Surya¹, Hasan Maksum², Waskito³

¹ Institut Teknologi Mitra Gama, Duri, Indonesia

^{2,3} Universitas Negeri Padang, Padang, Indonesia

*Email: candrasurya@gmail.com (Corresponding Author)



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ABSTRAK

This study aims to analyze the alignment between vocational high school graduates' competencies and industry needs using a data mining approach. The research is motivated by the increasing gap between graduates' skills and labor market demands in the era of rapid technological development. A quantitative method was employed, with data collected from 90 vocational high school students using a structured questionnaire. The analysis includes descriptive statistics, classical assumption tests, multiple linear regression, and data mining classification techniques to identify patterns of alignment. The results show that graduates' competencies have a positive and significant effect on alignment level, while industry needs have a significant but negative effect, indicating that increasing industry demands may reduce alignment if competencies are not improved. Simultaneously, both variables significantly influence alignment, although the coefficient of determination ($R^2 = 0.131$) indicates a relatively low explanatory power. This suggests that other factors also contribute to alignment. The findings highlight the importance of strengthening competency-based education and enhancing collaboration between vocational schools and industry. The use of data mining provides a data-driven approach to better understand alignment patterns and support decision-making in curriculum development.

INTRODUCTION

The rapid development of industry in the era of globalization and the Industrial Revolution 4.0 has significantly increased the demand for highly competent human resources who are aligned with the evolving needs of the labor market. Technological transformations, including automation, digitalization, and the integration of artificial intelligence, have reshaped job structures and required skill sets across various sectors (Li et al., 2026; Rosina et al., 2021). In this context, Vocational High Schools (Sekolah Menengah Kejuruan/SMK) play a crucial role in preparing graduates who are expected to be work-ready and capable of meeting industry demands. However, in reality, there is still a noticeable gap between the competencies possessed by SMK graduates and those required by employers (Ramsarup et al., 2023; Suseno et al., 2025).

This mismatch is often reflected in the relatively high unemployment rate among vocational school graduates compared to other levels of education. One of the primary causes of this issue is the lack of alignment between the curriculum implemented in SMKs and the dynamic needs of the industry (Rahmadhani et al., 2022; Yusuf et al., 2024). While SMKs emphasize technical and practical skills, many industries require not only technical expertise but also adaptability, problem-solving abilities, and familiarity with the latest technological developments. As a result, graduates may struggle to meet industry expectations despite having completed vocational education (Veal, 2024).

The concept of competency alignment is essential in ensuring that educational outputs are relevant to labor market demands. Competency alignment refers to the degree to which the knowledge, skills, and attitudes acquired by students match the qualifications required in the workplace (Jokić et al., 2024; Riyanto et al., 2025). When alignment is achieved, graduates are more

likely to be absorbed into the workforce efficiently. Conversely, a lack of alignment leads to skill gaps, reduced employability, and inefficiencies in both the education and employment sectors (Lupikawaty et al., 2025).

To address this issue, a systematic and data-driven approach is needed to analyze the extent of compatibility between SMK graduates' competencies and industry requirements. One promising method is the application of data mining techniques (Massi et al., 2026). Data mining enables the extraction of meaningful patterns, relationships, and insights from large datasets, making it a powerful tool for educational and workforce analysis. By utilizing data mining, researchers can identify trends, detect mismatches, and uncover hidden relationships between variables related to graduate competencies and industry expectations (Riyanto et al., 2025b).

Various data mining techniques, such as clustering, classification, and association rule mining, can be applied to evaluate competency alignment. For instance, classification algorithms can be used to categorize graduates based on their level of suitability for specific industry roles, while clustering methods can group similar competency profiles to identify patterns of strengths and weaknesses among graduates. These insights can provide valuable information for educators, policymakers, and industry stakeholders in designing more relevant curricula and training programs (Aljohani et al., 2022).

Furthermore, the use of a data mining approach allows for a more objective and evidence-based evaluation compared to traditional assessment methods. It enables stakeholders to move beyond subjective judgments and rely on empirical data in decision-making processes. This is particularly important in the context of continuous curriculum improvement and the development of industry-linked training programs that reflect real-world requirements (de Dios Oyarzún & Ramos Arellano, 2024).

In addition, strengthening the alignment between SMK competencies and industry needs is not only beneficial for individual graduates but also contributes to national economic development. A well-prepared workforce enhances productivity, reduces unemployment, and increases competitiveness in the global market. Therefore, it is essential to continuously evaluate and improve the relevance of vocational education through innovative approaches such as data mining (Li et al., 2026; Rosina et al., 2021).

Based on these considerations, this study aims to analyze the alignment between the competencies of SMK graduates and the needs of the industry using a data mining approach. The findings of this research are expected to provide insights into the extent of competency gaps and offer recommendations for improving vocational education systems. Ultimately, this study seeks to support the development of a more responsive and industry-oriented education system that can produce graduates who are truly ready to enter the workforce.

METHOD

This study uses a quantitative approach to analyze the alignment between vocational high school graduates' competencies and industry needs using a data mining approach. The quantitative method is applied to examine patterns and relationships between variables objectively through statistical and computational analysis (Sugiyono, 2019).

The population of this study consists of vocational high school (SMK) students. The sample size is determined using the Slovin formula, which is commonly used when the population size is known (Sevilla et al., 2007). The formula is as follows:

$$n = \frac{N}{1 + N(e)^2}$$

Where:

n = sample size

N = population size
e = margin of error

Assuming the total population (N) is 116 students and the margin of error (e) is 5% (0.05), the calculation is:

$$n = \frac{116}{1 + 116(0.05)^2} n = \frac{116}{1 + 116(0.0025)} n = \frac{116}{1 + 0.29} n = \frac{116}{1.29} = 89.92 \approx 90$$

Thus, the number of samples used in this study is 90 respondents. The sampling technique applied is purposive sampling, where respondents are selected based on specific criteria, namely final-year students who are considered close to entering the workforce and have completed most of their vocational training (Sugiyono, 2019).

The data used in this study are primary data collected through structured questionnaires and supported by secondary data from school and industry references. The questionnaire uses a Likert scale to measure variables related to graduates' competencies and industry needs. Graduate competencies include technical skills, academic knowledge, and basic professional abilities, while industry needs include job skill requirements, adaptability, communication, and work attitudes. The use of the Likert scale allows researchers to quantify perceptions and attitudes systematically (Sekaran & Bougie, 2016).

Data analysis is conducted in several stages. First, descriptive statistical analysis is used to describe respondent characteristics and the general distribution of variables. Second, data preprocessing is performed, including data cleaning and transformation, which are essential steps in data mining (Han, Kamber, & Pei, 2012).

Furthermore, data mining techniques are applied, particularly classification algorithms such as Decision Tree, Naive Bayes, and Support Vector Machine (SVM), to analyze the alignment between graduates' competencies and industry needs. These algorithms are used to classify whether students' competencies are aligned or not aligned with industry demands. According to Han et al. (2012), classification techniques are effective for predicting categorical outcomes and identifying hidden patterns in data.

Model evaluation is carried out using accuracy, precision, and recall to assess the performance of the classification models. The results of this analysis are expected to provide insights into the level of alignment between vocational graduates' competencies and industry requirements, as well as support data-driven decision-making for curriculum development.

RESULT AND DISCUSSION

Result

Descriptive Statistical Analysis

Table 1. Descriptive Statistical Analysis Statistics

		Sex	Sex	Class/Level
N	Valid	90	90	90
	Missing	0	0	0
Mean		2.34	1.74	2.17
Median		2.00	2.00	2.00
Mode		2	2	2
Std. Deviation		.962	.439	.738
Minimum		1	1	1
Maximum		4	2	3
Sum		211	157	195

Table 1 presents the descriptive statistical analysis of respondents' characteristics, including age, gender, and class/level, as the initial stage in analyzing the alignment between vocational high school graduates' competencies and industry needs using a data mining approach. All 90 observations are valid with no missing data, indicating a reliable dataset for further computational analysis.

The mean values indicate that respondents are mostly concentrated in the middle categories, supported by median and mode values of 2 across variables. This suggests a relatively homogeneous sample, which is beneficial for classification modeling because it reduces extreme bias in pattern recognition. The standard deviation values show moderate variability, especially in age (0.962), while gender is more homogeneous (0.439).

In the context of data mining, this descriptive analysis is important as a preprocessing step to understand data distribution before applying classification algorithms. A well-distributed dataset improves the accuracy of models in identifying patterns of alignment between students' competencies and industry requirements.

Classical Assumption Test

1. Normality Test

Table 2. Normality Test
One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		90
Normal Parameters ^{a,b}	Mean	.0000000
	Std. Deviation	5.09005729
Most Extreme Differences	Absolute	.177
	Positive	.122
	Negative	-.177
Test Statistic		.177
Asymp. Sig. (2-tailed) ^c		.189
Monte Carlo Sig. (2-tailed) ^d	Sig.	.193
		99% Confidence Interval
	Lower Bound	.114
	Upper Bound	.157

a. Test distribution is Normal.

b. Calculated from data.

c. Lilliefors Significance Correction.

d. Lilliefors' method based on 10000 Monte Carlo samples with starting seed 299883525.

Table 2 shows the normality test results using the Kolmogorov-Smirnov method. The significance value (0.189) is greater than 0.05, indicating that the residual data are normally distributed. This fulfills the normality assumption, ensuring that the dataset is appropriate for further regression and data mining analysis.

2. Multicollinearity Test

Table 3. Multicollinearity Test Coefficients^a

Model		Collinearity Statistics	
		Tolerance	VIF
1	Graduates' Competencies (X1)	.707	1.415
	Industry Needs (X2)	.707	1.415

a. Dependent Variable: Alignment Level (Y)

Table 3 presents the results of the multicollinearity test, which aims to examine whether there is a high correlation between the independent variables, namely graduates' competencies (X1) and industry needs (X2), in explaining the alignment level (Y). Multicollinearity can affect the stability and interpretability of regression coefficients, making it important to ensure that independent variables are not excessively correlated.

The results show that both variables have a tolerance value of 0.707, which is well above the minimum threshold of 0.10. This indicates that a substantial proportion of the variance in each independent variable is not explained by the other variable. In addition, the Variance Inflation Factor (VIF) values for both variables are 1.415, which are far below the critical limit of 10. This suggests that there is no significant multicollinearity problem in the model.

In the context of this study, the absence of multicollinearity implies that graduates' competencies and industry needs can independently contribute to explaining the level of alignment. This is important for both regression and data mining analysis, as it ensures that classification algorithms can accurately identify patterns without distortion caused by overlapping information between variables.

3. Heteroscedasticity test

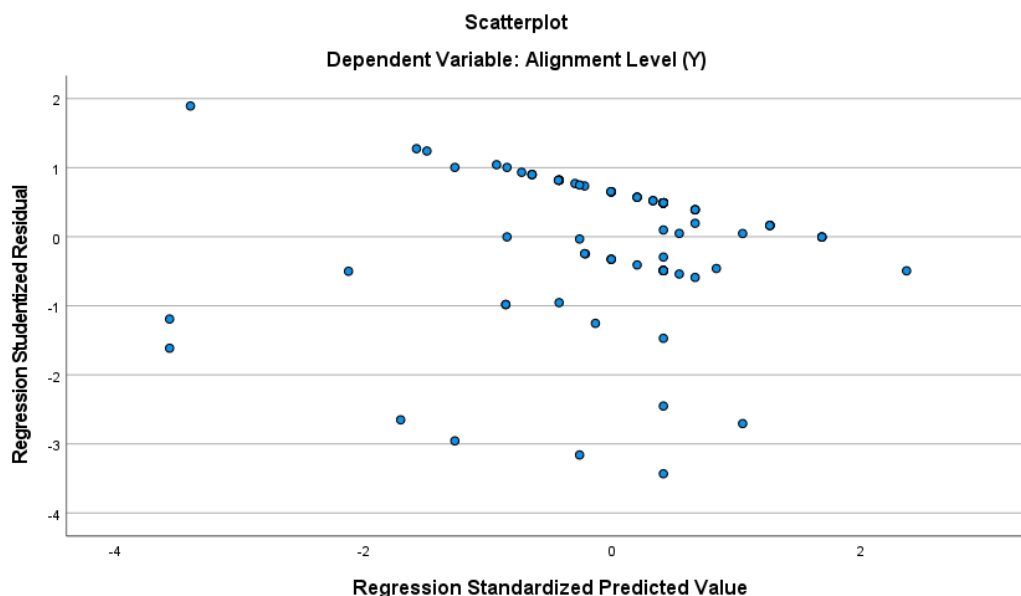


Figure 1. Results of heteroscedasticity test with scatterplot
Source: Output SPSS (2026)

The results of the heteroscedasticity test using a scatterplot show that the points are randomly distributed above and below zero without any particular pattern. This indicates that there is no heteroscedasticity, thus confirming that the regression model in this study is suitable.

for further analysis.

Multiple Linear Regression Test

Table 4. Result of Multiple Linear Regression Tes

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	18.351	2.404		7.634	.000
	Graduates' Competencies (X1)	.418	.116	.430	3.615	.001
	Industry Needs (X2)	-.252	.117	-.255	-2.147	.035

a. Dependent Variable: Alignment Level (Y)

Table 4 presents the results of the multiple linear regression analysis, which examines the effect of graduates' competencies (X1) and industry needs (X2) on the alignment level (Y). The regression equation can be formulated as:

$$AL = 18.351 + (0.418) (\text{Graduates' Competencies}) - (0.252) (\text{Industry Needs}) + \varepsilon$$

The constant value of 18.351 indicates the baseline level of alignment when both independent variables are assumed to be zero. The coefficient of graduates' competencies (0.418) shows a positive and significant effect on alignment level, with a t-value of 3.615 and a significance of 0.001 ($p < 0.05$). This means that higher competencies among graduates increase the level of alignment with industry needs.

In contrast, the coefficient of industry needs (-0.252) shows a negative but significant effect, with a t-value of -2.147 and a significance of 0.035. This suggests that as industry demands become more complex or higher, the alignment level tends to decrease if graduates' competencies do not adequately match those expectations.

The standardized coefficients (Beta) indicate that graduates' competencies (0.430) have a stronger influence compared to industry needs (-0.255). Overall, these results highlight the importance of improving students' competencies to achieve better alignment with evolving industry requirements.

Hypothesis Testing

1. T-Test (Partial)

Table 5. Results of the T-test (Partial)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	18.351	2.404		7.634	.000
	Graduates' Competencies (X1)	.418	.116	.430	3.615	.001
	Industry Needs (X2)	-.252	.117	-.255	-2.147	.035

a. Dependent Variable: Alignment Level (Y)

Table 5 presents the results of the t-test (partial test), which is used to examine the individual effect of each independent variable – graduates' competencies (X1) and industry needs (X2) – on

the dependent variable, namely the alignment level (Y).

The results show that graduates' competencies (X1) have a t-value of 3.615 with a significance level of 0.001, which is less than 0.05. This indicates that graduates' competencies have a positive and statistically significant effect on the alignment level. The positive regression coefficient (0.418) means that an increase in graduates' competencies will improve the level of alignment with industry needs. This finding highlights the importance of strengthening students' technical knowledge and skills to better match labor market demands.

On the other hand, industry needs (X2) have a t-value of -2.147 with a significance level of 0.035, which is also below 0.05. This indicates that industry needs have a significant but negative effect on alignment level. The negative coefficient (-0.252) suggests that higher or more complex industry demands may reduce alignment if graduates' competencies are not sufficiently developed.

Overall, both variables significantly influence alignment, but in different directions, emphasizing the need to balance competency development with evolving industry requirements.

2. F-Test (imultaneous)

Table 6. F test results (Simultaneous)
ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	347.783	2	173.891	6.561	.002 ^b
	Residual	2305.873	87	26.504		
	Total	2653.656	89			

a. Dependent Variable: Alignment Level (Y)

b. Predictors: (Constant), Industry Needs (X2), Graduates' Competencies (X1)

Table 6 presents the results of the F-test (simultaneous test), which is used to determine whether the independent variables – graduates' competencies (X1) and industry needs (X2) – collectively have a significant effect on the alignment level (Y).

The results show that the F-value is 6.561 with a significance level of 0.002, which is less than 0.05. This indicates that the regression model is statistically significant, meaning that graduates' competencies and industry needs simultaneously influence the alignment level. Therefore, the proposed model is valid and can be used to explain the relationship between variables.

The regression sum of squares (347.783) represents the variation in alignment level explained by the model, while the residual sum of squares (2305.873) indicates the variation not explained by the independent variables. Although the explained variation is smaller than the unexplained portion, it still demonstrates that the model has meaningful explanatory power.

In the context of this study, these results suggest that alignment between vocational graduates' competencies and industry needs cannot be explained by a single factor alone. Instead, both variables must be considered together, as their interaction plays an important role in determining how well graduates meet industry expectations.

R2 Test (Coefficient of Determination)

Table 7. R2 Test Results
Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.362 ^a	.131	.111	5.148

- a. Predictors: (Constant), Industry Needs (X2), Graduates' Competencies (X1)
- b. Dependent Variable: Alignment Level (Y)

Table 7 presents the results of the coefficient of determination (R^2), which measures how well the independent variables – graduates' competencies (X1) and industry needs (X2) – explain the variation in the dependent variable, namely the alignment level (Y).

The R value of 0.362 indicates a low to moderate relationship between the independent variables and the alignment level. The R Square value of 0.131 shows that 13.1% of the variation in alignment level can be explained by graduates' competencies and industry needs. Meanwhile, the adjusted R Square of 0.111 provides a more accurate estimate by considering the number of variables in the model, indicating that 11.1% of the variation is explained after adjustment.

The remaining 86.9% of the variation is influenced by other factors not included in this study, such as curriculum relevance, internship experience, technological adaptation, or individual motivation. The standard error of the estimate (5.148) reflects the average deviation of observed values from the regression line.

Overall, these results suggest that while the model is statistically significant, its explanatory power is relatively limited, indicating the need to include additional variables for a more comprehensive analysis of alignment.

Discussion

1. The Influence of Graduates' Competencies on Alignment Level

Based on the results of the t-test, graduates' competencies (X1) have a positive and statistically significant effect on the alignment level (Y), as indicated by a t-value of 3.615 and a significance level of 0.001 ($p < 0.05$). This finding confirms that graduates' competencies play a crucial role in determining how well vocational high school outcomes align with industry needs. The regression coefficient (0.418) suggests that any increase in competencies will directly improve the alignment level, meaning that better-prepared graduates are more capable of meeting labor market expectations.

This result is in line with the competency theory proposed by Spencer and Spencer (1993), which defines competence as an underlying characteristic that leads to effective or superior performance in a job. In the context of vocational education, competencies include technical knowledge, practical skills, and problem-solving abilities that are directly required in the workplace. Bloom (1956) also supports this view through the taxonomy of educational objectives, emphasizing that learning outcomes in cognitive and psychomotor domains are essential for developing job-relevant skills.

Furthermore, Boyatzis (2008) highlights that effective performance occurs when individual competencies align with organizational demands. This implies that improving graduates' competencies will reduce the mismatch between education and industry. The findings of this study reinforce the importance of competency-based curricula, industry-oriented training, and practical learning experiences such as internships.

Therefore, vocational institutions must continuously update their training systems to ensure that students acquire relevant competencies. Strengthening technical and professional skills will significantly enhance the alignment between graduates and industry requirements, ultimately increasing employability and reducing skill gaps in the labor market.

2. The Influence of Industry Needs on Alignment Level

The t-test results indicate that industry needs (X2) have a significant but negative effect on the alignment level, as shown by a t-value of -2.147 and a significance level of 0.035 ($p < 0.05$). The negative regression coefficient (-0.252) suggests that as industry demands become more

advanced or complex, the alignment level tends to decrease if graduates' competencies are not sufficiently developed to match these evolving requirements.

This finding can be explained through Human Capital Theory proposed by Becker (1993), which emphasizes that individuals must continuously improve their skills and knowledge to remain relevant in a dynamic labor market. When industry needs change rapidly due to technological advancements, automation, and globalization, educational institutions often face challenges in updating curricula at the same pace. This results in a gap between what students learn and what employers require.

Yorke (2006) further explains that employability is determined by the alignment between graduate attributes and labor market expectations. If industry demands increase without corresponding improvements in education, misalignment becomes inevitable. This study confirms that industry needs are not static; instead, they continuously evolve and raise the standards required of graduates.

Therefore, the negative relationship found in this study does not imply that industry needs are detrimental, but rather highlights the urgency for educational institutions to adapt more quickly. Strong collaboration between schools and industry partners is essential to ensure that training programs remain relevant. Without such alignment efforts, graduates may struggle to meet industry expectations despite having formal qualifications.

3. The Simultaneous Influence of Graduates' Competencies and Industry Needs on Alignment Level

The results of the F-test demonstrate that graduates' competencies and industry needs simultaneously have a significant effect on the alignment level, as indicated by an F-value of 6.561 and a significance level of 0.002 ($p < 0.05$). This confirms that both variables collectively influence how well vocational graduates' competencies align with industry requirements. The regression model is therefore valid in explaining the relationship between these variables.

This finding supports the employability framework proposed by Yorke (2006), which emphasizes that work readiness and alignment are influenced by a combination of individual competencies and external labor market demands. Similarly, Jackson (2014) argues that employability is achieved when graduates possess both relevant technical skills and the ability to meet industry expectations. This means that alignment is not determined by a single factor but by the interaction between internal (competency) and external (industry needs) factors.

However, the coefficient of determination ($R^2 = 0.131$) indicates that only 13.1% of the variation in alignment level is explained by these two variables. This suggests that alignment is a complex phenomenon influenced by many other factors, such as curriculum relevance, internship experience, institutional quality, technological adaptation, and individual motivation.

In the context of data mining, these results highlight the importance of incorporating additional variables to improve model accuracy and predictive power. The relatively low explanatory power also suggests that future research should explore broader determinants of alignment.

Overall, the simultaneous effect of graduates' competencies and industry needs underscores the importance of a holistic approach in vocational education. Strengthening competencies while continuously adapting to industry changes is essential to achieve better alignment and improve graduates' competitiveness in the labor market.

CONCLUSION

This study concludes that the alignment between vocational high school graduates' competencies and industry needs is significantly influenced by both factors. Graduates' competencies have a positive and significant effect on alignment, indicating that stronger technical and practical skills improve compatibility with industry requirements. In contrast, industry needs show a significant negative effect, suggesting that rapidly increasing job demands

may reduce alignment if competencies are not adequately developed. Simultaneously, both variables significantly affect alignment, although their explanatory power is relatively low ($R^2 = 0.131$). Therefore, other factors also play important roles. Overall, improving competencies and strengthening industry collaboration are essential to enhance alignment outcomes..

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