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Implementation of Vocational School Management Model to Improve School Performance

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ABSTRACT

This study aims to test the implementation of the Vocational High School (SMK) management model and identify the relationship between academic-industry management, business and industry partnerships (DUDI), sustainable quality management, and human resource management with school performance. The study uses a quantitative approach with an explanatory survey design on 50 observations at SMK in Tomohon City and analyzes six latent constructs measured through 52 indicators using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS 4. The results show that academic-industry management has a positive effect on the SMK Management Model ($\beta = 0.215$; $p = 0.046$), while DUDI partnership management has a positive effect on the SMK Management Model ($\beta = 0.687$; $p = 0.001$) and SMK Performance ($\beta = 0.426$; $p < 0.001$). Human resource management also has a positive effect on the SMK Management Model ($\beta = 0.307$; $p = 0.012$) and SMK Performance ($\beta = 0.067$; $p = 0.011$), while sustainable quality management shows a strong direct relationship with SMK Performance ($\beta = 0.621$; $p < 0.001$), but does not show a significant relationship with the SMK Management Model ($p = 0.165$). The SMK Management Model has a negative and significant relationship with SMK Performance ($\beta = –0.102$; $p < 0.001$), a finding that needs to be interpreted with caution due to indications of collinearity and closeness between the constructs. The model explains 71.4% of the variance in the SMK Management Model and 99.2% of the variance in SMK Performance, but the high apparent power needs to be read in conjunction with the HTMT and VIF findings which indicate issues of discriminant validity and collinearity. This study contributes to the development of vocational education management studies by showing that SMK performance needs to be understood as a result of the relationship between academic orientation towards the world of work, DUDI partnerships, sustainable quality management, and human resource development, while emphasizing the need for refinement of

model specifications and robustness testing on larger samples before the model can be generalized more widely.

Keywords: DUDI Partnership, Human Resource Management, School Performance, Sustainable Quality Management, Vocational High School Management.

INTRODUCTION

Vocational High Schools (SMK) have a specific mandate: to produce graduates who are work-ready, entrepreneurial, and ready to continue their education. However, the current challenges facing vocational schools are complex: a skills gap with industry, limited practical facilities, teachers lacking technological updates, and suboptimal graduate absorption rates. Statistics Indonesia (BPS) data from 2023 shows that the TPT for vocational high school graduates is still 9.31%, the highest compared to other levels. This means that school performance is not optimal. Vocational high school performance cannot be improved solely through classroom learning. An appropriate management model is needed to systematically manage the curriculum, teachers, facilities, industry partnerships, and school culture. Therefore, implementing a relevant vocational high school management model is key to meeting the demands of linking and matching with the world of work and improving graduate quality.

Vocational High Schools (SMK) occupy a strategic position in the Indonesian education system because their mandate extends beyond students' academic achievement to preparing graduates with work competencies, professional character, adaptability, and the capacity to continue their education or develop businesses. With this mandate, SMK performance is essentially the result of a management system that connects school planning, curriculum and learning management, human resource development, practice facility management, partnerships with the business and industrial world (DUDI) and the world of work, quality assurance, and monitoring of graduate outcomes. Therefore, the issue of SMK performance should not be understood solely as a matter of classroom learning, but rather as a matter of how all school resources and processes are managed in an integrated manner to produce vocational education services that are relevant to the needs of society and the job market.

The national policy context indicates that strengthening the management and relevance of vocational high schools (SMK) has become a key agenda in the development of vocational education. SMK revitalization is aimed at strengthening the connection between schools and the world of work through curriculum alignment, improving the competency of educators and education personnel, strengthening collaboration with local governments and the business/industry sector, implementing competency certification, and providing a practice environment that approaches industry standards. The link and match policy was then developed more operationally through the 8+i framework, which emphasizes, among other things, curriculum alignment with industry, real-world project-based learning, practitioner involvement, fieldwork practice, competency certification, and involvement of the world of work in school development. This policy direction demonstrates that the quality of vocational high schools is increasingly determined by the school's ability to build a management ecosystem that integrates academic needs with the needs of the world of work, rather than solely by the administrative existence of expertise programs (Ministry of Education and Culture, 2020, 2021).

At the national level, these challenges remain relevant because the existence of vocational high schools (SMK) does not automatically guarantee a match between education and job market needs. Statistics Indonesia (BPS) regularly places vocational education in the context of human

resource quality, school-to-work transition, and the match of skills to job opportunities. The 2024 Education Statistics also show that education quality needs to be viewed not only in terms of access and the number of educational units, but also in terms of teacher conditions, facilities, service processes, and educational achievements at various levels. Therefore, improving vocational high school performance requires a management approach that consistently connects input, process, partnerships, learning quality, and graduate outcomes (Central Statistics Agency, 2024). This challenge becomes increasingly important as technological changes, the digitalization of work processes, demands for soft skills, and increasingly specific competency requirements force schools to continually update their curricula, teacher competencies, practical facilities, and relationships with the world of work.

This problem is also evident in employment indicators. Statistics Indonesia (BPS) data shows that in August 2024, the national open unemployment rate (TPT) based on highest education attainment was still relatively high among vocational high school graduates, at 6.81 percent, compared to several other educational groups. This figure does not imply that the entire unemployment problem is caused by schools, as job opportunities, economic structure, location, work experience, and macroeconomic conditions also influence it. However, the data provides a strong rationale for re-examining how schools manage the relevance of competencies, student work experience, partnerships with the workforce, and graduates' transitions to employment, entrepreneurship, or further education. In other words, vocational high school performance needs to be understood as the result of the interaction between the quality of internal school management and the school's ability to respond to a changing external environment (Central Statistics Agency, 2024).

In the context of North Sulawesi, the relevance of vocational education also has a workforce dimension that requires attention. The Statistics Indonesia (BPS) of North Sulawesi Province reported that, based on the August 2023 National Labor Force Survey (Sakernas), the Open Vocational School (TPT) for the population with secondary and higher education reached 9.35 percent. BPS also emphasized the need to map graduate potential with emerging job opportunities and strengthen tracer studies to determine the waiting period and conditions of graduates after completing their education. These statistical policy findings reinforce the argument that vocational school management needs to be directed toward a closer relationship between expertise programs, workplace needs, practical experience, teacher competency, and information on graduate track records. Within the framework of educational management, this need places academic-industry management and partnership management as integral parts of school performance, not merely additional activities (BPS of North Sulawesi Province, 2024).

More specifically, Tomohon City provides an interesting context for this research because its vocational education structure is relatively concentrated. The 2025 Tomohon Village Potential Statistics recorded seven vocational high schools (SMK) in Tomohon City, consisting of one public and six private vocational high schools. Their distribution is uneven across regions: five vocational high schools are in Central Tomohon District, one public vocational high school is in West Tomohon, and one vocational high school is in North Tomohon. South Tomohon and East Tomohon are not listed as having any vocational high schools in the educational infrastructure table (BPS Kota Tomohon, 2025). This concentration is managerially important because access to facilities, job networks, student mobility, and partnership opportunities can vary across regions. The dominance of vocational high schools in Central Tomohon also indicates that the vocational education ecosystem in this city needs to be viewed not only in terms of the number of schools, but also in terms of each school's capacity to develop program excellence, partnership networks, and graduate performance.

The employment situation in Tomohon City further underscores this urgency. The Tomohon City development planning document indicates that the city's Open to Work (TPT) remains a problem and, during the period under review, was above the North Sulawesi Province and national averages. The document also identifies an imbalance between the workforce and job opportunities, a low proportion of workers with competency certificates, and the need to improve the quality of human resources and professional skills. The same document states that the average length of schooling is approximately 10.74 years. These conditions indicate that the development of vocational education in Tomohon must not be solely focused on increasing the number of graduates but must also ensure that graduates possess demonstrable competencies, relevant work experience, and the ability to adapt to the structure of available job opportunities in the region (Tomohon City Government, 2025).

This local context becomes even more important when linked to the economic characteristics of Tomohon City. The 2025 Village Potential Statistics show the presence of 44 villages/sub-districts with micro and small industries and four industrial centers. Tomohon City also has trade, banking, and accommodation facilities spread across several sub-districts. This structure provides space for vocational high schools (SMK) to build partnerships not only with large-scale companies but also with local businesses, in the service sector, trade, tourism, creative industries, and micro-small businesses. Therefore, the concept of the world of work for vocational high schools in Tomohon needs to be understood more broadly in accordance with the characteristics of the regional economy. Effective partnership management should be able to map the competency needs of various segments of the local workforce, build productive collaborations, provide practical experience, and connect graduates with realistic employment or entrepreneurial opportunities (BPS Kota Tomohon, 2025).

Regional education data also demonstrates that the relationship between schools and the workplace is an indicator that requires explicit attention. The 2025 Tomohon City Education Report lists "Vocational High School Graduate Absorption" and "Partnership and Alignment of Vocational High Schools with the World of Work" as key indicators at the vocational high school level. For the partnership and alignment indicator, results for general vocational high schools in Tomohon City were reported as good, but experienced a decline compared to the previous year. Meanwhile, the vocational high school graduate absorption indicator was reported as good. This information is important because it demonstrates that discussions of vocational high school performance should not focus solely on weaknesses, but also on how existing practices can be maintained, expanded, and systematically managed to prevent decline. In this study, school performance is therefore positioned as an outcome that needs to be explained through the quality of academic-industry management, partnerships, sustainable quality, and human resource management.

Based on this context, the main research question is not simply whether vocational schools (SMK) have partnership programs, industrial curricula, productive teachers, or quality assurance activities, but rather whether all these components are integrated into a consistent management model. Academic-industry management is needed to ensure that the curriculum, learning, work practices, and graduate competencies remain relevant to the needs of the workplace. Partnership management is necessary so that relationships with DUDI (industrial and industrial) evolve from simply signing cooperation agreements to collaborations that result in learning, practice, certification, curriculum development, and job opportunities. Continuous quality management is needed so that schools have data-driven monitoring, evaluation, and improvement mechanisms. Meanwhile, human resource management is needed to ensure that teachers and education personnel continue to develop in line with changing competencies demanded by the workplace. These four dimensions can be conceptually integrated through a systematic management cycle, starting from planning, organizing, implementing, monitoring, and evaluating.

This study stems from the need to test the integration of these four dimensions in the real context of vocational high schools (SMKs) in Tomohon City. The research document that serves as the basis for this study specifically positions Academic-Industrial Management (MAI), Business and Industrial Partnership Management (MKD), Sustainable Quality Management (MMB), and Human Resource Management (HRM) as constructs that explain the SMK Management Model, and examines their relationship to SMK performance. This framework is consistent with the characteristics of vocational education, which requires integration between internal school processes and external demands of the workplace. Thus, this study not only seeks to produce a descriptive picture of SMK management but also empirically tests the relationships between these management components and their contributions to school performance.

The research gap to be addressed lies in the need to develop a contextual vocational high school management model. Many approaches to improving the quality of vocational education emphasize the importance of linkages and matches, teacher empowerment, practical facilities, certification, and industry partnerships. However, in school management practice, these components are often separate programs and are not always managed as a unified performance system. This research therefore views vocational high school performance as a result of the interconnectedness between academic-industry management, workplace partnerships, sustainable quality, and human resource management. Focusing on Tomohon City provides contextual value because the number and distribution of vocational high schools, the local economic structure, employment conditions, and the need for workforce competency development have their own unique characteristics.

Based on the above description, this research has both academic and practical relevance. Academically, this research seeks to enrich the study of vocational education management by examining the relationship between work-oriented school management dimensions and school performance. Practically, the research results are expected to serve as a basis for principals, teachers, vocational high school administrators, the Education Office, and partners in the workforce to strengthen data-driven vocational high school governance and address regional needs. In the Tomohon context, the developed model is expected to help schools integrate academic planning, human resource development, partnerships, quality assurance, and performance evaluation so that vocational high schools not only produce graduates but also graduates with relevant, adaptive competencies and better transition opportunities into the world of work, entrepreneurship, and further education.

METHOD

Research Design and Approach

This study uses a quantitative approach with an explanatory survey design to examine the structural relationship between vocational school management dimensions and school performance. The research design is directed at explaining the relationship between Academic-Industrial Management (MAI), Business and Industry Partnership Management (MKD), Sustainable Quality Management (MMB), Human Resource Management (MSD), Vocational High School Management Model, and Vocational High School Performance. The research framework was developed based on the assumption that vocational school performance is not only a consequence of the school's internal management, but also related to the school's ability to integrate academic processes with the needs of the workplace, build productive partnerships with the business and industrial world (DUDI), develop human resources, and implement mechanisms for continuous quality improvement.

The research was conducted in the context of Vocational High Schools (SMK) in Tomohon City, North Sulawesi. The selection of this context was based on the characteristics of the vocational education ecosystem in Tomohon City, which consists of seven vocational high schools (SMK), one public and six privates. This context provides a relevant empirical environment for testing a management model that connects internal school management with workplace demands and school performance.

The study used Partial Least Squares Structural Equation Modeling (PLS-SEM) as the primary analysis technique. PLS-SEM was chosen because the study involved a number of latent constructs represented by multiple indicators, as well as a structural model encompassing direct and indirect relationships between constructs. This approach allows the study to evaluate the quality of the measurement model while simultaneously estimating the structural relationships between latent variables. However, the use of PLS-SEM is not considered an automatic guarantee of model validity. Therefore, evaluations were conducted in stages, including reliability, convergent validity, discriminant validity, collinearity, model explanatory power, effect size, relationship significance, and indirect effects.

Population, Sample, and Unit of Analysis

The research analysis unit is the practice and management of management at the vocational high school level, with empirical data obtained through a survey instrument. The research dataset consists of 50 observations (N = 50) used to estimate a model that includes six latent constructs and 52 indicators. The six constructs are Academic-Industrial Management, Business and Industrial Partnership Management, Sustainable Quality Management, Human Resource Management, Vocational High School Management Model, and Vocational High School Performance.

This data structure results in a relatively complex empirical model compared to the sample size. Therefore, the estimation results are treated as contextual empirical evidence regarding the relationships between constructs within the vocational high schools studied, rather than as a basis for broad statistical generalizations to all vocational high schools in Indonesia. This approach is important given that sample size and local context characteristics are part of the inferential limitations of the study.

Research Construct and Conceptual Model

The research model consists of six latent constructs. Four constructs are placed as exogenous variables, namely:

Academic-Industrial Management (MAI), which represents the management of academic aspects of schools that are oriented towards the needs and characteristics of the world of work;

Management of Business and Industry Partnerships (MKD), which represents the management of school relations and collaboration with DUDI;

Continuous Quality Management (SQM), which represents a mechanism for continuous monitoring, evaluation, control and improvement of quality;

Human Resource Management (HRM), which represents the management and development of school human resources to suit the needs of implementing vocational education.

The other two constructs are endogenous constructs: the Vocational High School Management Model **and** Vocational High School Performance. The Vocational High School Management Model is positioned as an intermediate endogenous construct connecting the four main management dimensions with Vocational High School Performance, while Vocational High School Performance is positioned as the final outcome construct in the model. This structure allows for testing of both direct and indirect influences through the Vocational High School Management Model.

Structurally, the research model is formulated in two equations:

$$SMK\ Management\ Model = \beta_1 MAI + \beta_2 MKD + \beta_3 MMB + \beta_4 MSD + \zeta_1$$
$$Vocational\ High\ School\ Performance = \beta_5 MAI + \beta_6 MKD + \beta_7 MMB + \beta_8 MSD + \beta_9\ Vocational\ High\ School\ Management\ Model + \zeta_2$$

The β coefficient represents the standardized path coefficient, while ζ represents the structural residual. This specification allows the study to simultaneously test the contribution of each management dimension to the vocational school management model and school performance.

Instruments and Operationalization of Variables

Data collection was conducted using an instrument consisting of 52 indicators representing six research constructs. The distribution of indicators consisted of 11 indicators for Academic-Industrial Management, seven indicators for DUDI Partnership Management, seven indicators for Sustainable Quality Management, seven indicators for Human Resource Management, eight indicators for the Vocational High School Management Model, and 12 indicators for Vocational High School Performance.

These indicators are used to represent latent constructs that cannot be directly observed. In the measurement model evaluation process, the study treated the constructs as reflective indicator-based constructs according to the model specifications used in SmartPLS. Evaluation of indicator quality is not only based on individual outer loading values, but also considers the construct's internal consistency, Average Variance Extracted (AVE), construct validity, and the indicator's theoretical relevance.

This approach is important because several indicators in the model have outer loading values below 0.70. The lowest loading values for each construct range from 0.567 to 0.775. However, indicators are not automatically eliminated based solely on their loading values, as elimination decisions must consider their contribution to the construct's reliability, AVE, and conceptual scope.

Data Analysis Procedure

Data analysis was performed using SmartPLS 4 with the PLS-SEM algorithm. The analysis was carried out in two main stages: measurement model evaluation **and** structural model evaluation**.** The separation of these two stages was used to ensure that the interpretation of structural relationships was carried out after the quality of the constructs and indicators had been adequately evaluated.

In the first stage, the measurement model was evaluated using several criteria. The internal consistency of the constructs was examined using Cronbach's alpha, rho_A, and composite reliability. Convergent validity was evaluated through outer loading and Average Variance Extracted (AVE). A loading value of around 0.70 or higher was used as a general guideline, while indicators with loadings between 0.40 and 0.70 were considered based on construct reliability, AVE, and theoretical justification. An AVE of 0.50 was used as a benchmark to assess whether the construct was able to explain an adequate proportion of the indicator's variance.

Discriminant validity was evaluated using the Heterotrait-Monotrait Ratio (HTMT)**.** HTMT was chosen because it is more sensitive in detecting discriminant validity issues than the Fornell-Larcker and cross-loading approaches. An HTMT value below 0.90 is used as a general guideline, with 0.85 being a more conservative criterion.

In the second stage, a structural model evaluation was conducted by examining collinearity, the coefficient of determination (R^2), the effect size (f^2), the path coefficient, statistical significance, and the direct and indirect effects. Collinearity was evaluated using the Variance Inflation Factor

(VIF), while R^2 was used to indicate the proportion of the endogenous construct's variance that can be explained by its predictor constructs. The effect size f^2 was used to evaluate the relative contribution of each predictor to the endogenous construct.

Bootstrapping and Hypothesis Testing

The significance of the path coefficients was tested using a two-tailed bootstrapping procedure at the 5% significance level. The test used the criteria of $p < 0.05$ and a t-statistic of approximately 1.96 as the two-sided test limit at $\alpha = 0.05$. In addition to the p-value and t-statistic, confidence intervals were used as additional information to evaluate the stability of the coefficient estimates.

The structural model tests seven main hypotheses. These hypotheses include the relationship between Academic-Industry Management, Industrial and Industrial Partnership Management, Sustainable Quality Management, and Human Resource Management on the SMK Management Model; the influence of the SMK Management Model on SMK Performance; and the direct influence of Industrial and Industrial Partnership Management and Sustainable Quality Management on SMK Performance. In addition to these main hypothetical paths, the empirical model also allows for the examination of the direct paths of MAI and MSD on SMK Performance as well as the indirect effects through the SMK Management Model.

Indirect effects analysis was used to evaluate whether the SMK Management Model acts as a mechanism linking specific management dimensions to SMK Performance. Mediation interpretation was based on the significance of the indirect effects and the direction of the coefficients, taking into account the direct relationships within the model. Thus, mediation was not determined solely based on the significance of a single path, but by considering the overall structure of the relationships within the model.

Robustness and Model Quality Evaluation

To enhance methodological rigor, the study did not rely solely on statistical significance. The evaluation also included examination of HTMT, VIF, R^2, f^2, confidence intervals, and model fit**.** This multidimensional approach was necessary because the research model contained conceptually related constructs, particularly between quality management practices, DUDI partnerships, management models, and school performance.

This evaluation also serves as a basis for interpreting the results cautiously. The research dataset shows that several pairs of constructs have high closeness based on HTMT, and several VIF values indicate potential collinearity. Therefore, path coefficients are understood as statistical relationships in the estimated model**,** not as evidence of experimental causality. The study used an observational survey design, so causal inference is limited by design characteristics, sample size, and the possibility of shared method variance.

Furthermore, out-of-sample predictive capability is not confirmed because PLSpredict output is not available in the analysis results that form the basis of the research. Thus, the research contribution is placed primarily on empirical testing of inter-construct relationships and the development of a conceptual model of vocational high school management in the context of Tomohon City, while predictive validation and generalization of the model require further research with larger samples and more diverse contexts.

Analysis Integrity and Bias Control

All statistical estimates in the study are based on the study responses as provided in the dataset. No changes, manipulations, or adjustments were made to the responses to achieve statistical significance. All coefficients, t-statistics, p-values, and model measurements are reported based on

the SmartPLS output used in the analysis. This approach is essential to maintain the integrity of the analysis and ensure that the study's conclusions are derived from the empirical data, not from fitting the data to a predetermined hypothesis.

Overall, the research methodological design integrates quantitative surveys, multidimensional latent constructs, and PLS-SEM to examine how Academic-Industrial Management, DUDI Partnership Management, Sustainable Quality Management, and Human Resource Management relate to the SMK Management Model and SMK Performance. This structure provides an empirical basis for understanding SMK management as a system that connects internal school processes with the demands of the workplace, while also providing an analytical framework for identifying direct and indirect relationships between these management components.

RESULTS AND DISCUSSION

This study focuses on the empirical significance of the PLS-SEM results of a study on the implementation of a Vocational High School (SMK) management model to improve school performance. The analysis goes beyond statistical decisions regarding hypotheses, but also connects path coefficients, model explanatory power, effect sizes, confidence intervals, discriminant validity, and collinearity with the logic of vocational education management. This approach is important because PLS-SEM should be reported through a series of measurement model and structural model evaluations, along with robustness checks that align with the research objectives (Hair et al., 2019).

The research data consists of 50 observations and 52 indicators that form six constructs, namely Academic-Industrial Management (MAI), Business and Industrial Partnership Management (MKD), Sustainable Quality Management (MMB), Human Resource Management (MSD), Vocational High School Management Model, and Vocational High School Performance. The structural model tests four predictors of the Vocational High School Management Model, as well as the influence of the four predictors and the Vocational High School Management Model on Vocational High School Performance. Thus, the empirical design allows for the reading of direct and indirect influences through the Vocational High School Management Model.

The results were interpreted with caution. Reliability and AVE values indicated adequate internal quality and convergent validity, but several HTMT values exceeded commonly used thresholds for discriminant validity. Furthermore, a number of structural and indicator VIFs were relatively high. These conditions do not invalidate the results entirely, but they limit how strongly path coefficients can be interpreted as truly separate relationships between constructs. Henseler et al. (2015) showed that HTMT is more sensitive than the Fornell-Larcker and cross-loading approaches in detecting discriminant validity issues.

Data Sources, Model Structure, and Analysis Procedures

This study used the SmartPLS 4 statistical application with the PLS-SEM algorithm to estimate composite-based models. PLS-SEM reporting separates the measurement model evaluation from the structural model, then assesses significance using bootstrapping and explains the apparent power and effect size. Hair et al. (2019) emphasized that PLS-SEM reporting should include the rationale for the method used, evaluation of the measurement model, the structural model, and relevant robustness procedures. SmartPLS also places HTML, loading, reliability, AVE, R^2, f^2, VIF, confidence interval, and predictive assessment as important parts of the evaluation.

The estimated model can be written as two structural equations:

SMK Management Model = β1 MAI + β2 MKD + β3 MMB + β4 MSD + ζ1
Vocational School Performance = β5 MAI + β6 MKD + β7 MMB + β8 MSD + β9 Vocational School Management Model + ζ2

Path coefficients are standardized coefficients. Significance was assessed using two-sided bootstrapping results at the 5% level, with statistical decisions based on $p<0.05$ and confidence intervals that do not cross zero. In this report, a two-sided 5% critical t-value of approximately 1.96 was used. SmartPLS results remain the primary source of reported t- and p-values. See Figure 1.

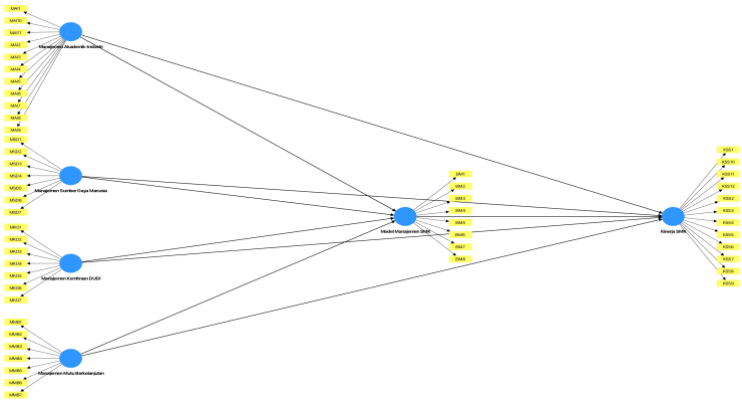

Figure 1. SEM-PLS structural model

This study presents the complete processing and interpretation of SEM-PLS. The analysis includes measurement model evaluation, structural model evaluation, bootstrapping, hypothesis testing, indirect effects, effect sizes, R^2, VIF, HTMT, and model fit. The analysis did not transform, manipulate, or adjust responses to achieve statistical significance. All figures are reported as they appear in the SmartPLS output.

The model contains six constructs: Academic-Industry Management, DUDI Partnership Management, Sustainable Quality Management, Human Resource Management, Vocational High School Management Model, and Vocational High School Performance. The estimated structure has four main predictors leading to the Vocational High School Management Model, the Vocational High School Management Model leading to Vocational High School Performance, and direct paths from the four predictors to Vocational High School Performance. With N=50, the measurement model shows strong internal consistency and the AVE of all constructs is above 0.50. However, there are significant issues with discriminant validity because several HTMTs are above 0.90, including the pairs of DUDI Partnership with Vocational High School Performance, Sustainable Quality with Vocational High School Performance, and Sustainable Quality with DUDI Partnership. In addition, several inner model VIFs exceed 5, indicating potential structural collinearity. In the structural model, the Vocational High School Management Model is explained by $R^2=0.714$, while Vocational High School Performance is explained by $R^2=0.992$. Several significant paths at $\alpha=5\%$, namely Academic-Industry → SMK Management Model, DUDI Partnership → SMK Performance, DUDI Partnership → SMK Management Model, Sustainable Quality → SMK Performance, Human Resources → SMK Performance, Human Resources → SMK Management Model, and SMK Management Model → SMK Performance. The Sustainable Quality → SMK Management Model path is not significant, nor is Academic-Industry → SMK Performance.

Mediation findings show that the indirect effect of the DUDI Partnership through the SMK Management Model is significant but negative, while the indirect effect of HR is also significant and negative. The indirect effects of Academic-Industry and Sustainable Quality are insignificant.

Because some direct and indirect relationships have different signs, mediation interpretation requires caution and cannot be simply labeled as positive or negative mediation.

SEM-PLS Methodological Framework

PLS-SEM is appropriate when research focuses on explaining relationships between constructs and developing predictive models, especially when the model has multiple constructs and structural paths. However, selecting PLS-SEM does not automatically guarantee the validity of the entire model. Construct validity, reliability, collinearity, apparent power, effect size, significance, and predictive power must still be examined.

In education and school management research, constructs such as management quality, partnerships with business and industry, human resource management, and school performance are latent concepts that are not directly observed. Therefore, indicators are used to represent the constructs. For reflective models, primary evaluations include outer loading, Cronbach's alpha, rho_A, composite reliability, AVE, and HTMT. Hair et al. (2019) explain that loadings around 0.70 or higher are commonly retained, but indicators between 0.40 and 0.70 may be considered based on their impact on AVE, reliability, and theoretical rationale. SmartPLS also currently emphasizes that loadings ≥0.70, reliability ≥0.70, and AVE ≥0.50 are common benchmarks. Therefore, the decision to remove an indicator should not be based solely on a single number. For discriminant validity, Henseler et al. (2015) introduced HTMT because Fornell-Larcker and cross-loadings can fail to detect some forms of construct ambiguity. SmartPLS recommends HTMT as the primary criterion, with values below 0.90 as a general benchmark and 0.85 as a more conservative criterion. For structural models, R^2 indicates the proportion of the endogenous construct variance explained by the predictor. f^2 indicates the relative contribution of a predictor to R^2. VIF is used to assess collinearity. Bootstrapping is used to obtain empirical sampling distributions so that coefficients can be tested through standard errors, t, p, and confidence intervals.

Measurement Model Evaluation: Outer Loading

The outer loading results show that most indicators have strong loadings. Vocational High School Performance has 12 indicators, Academic-Industrial Management has 11 indicators, Industrial and Industrial Partnerships has 7 indicators, Sustainable Quality has 7 indicators, Human Resources has 7 indicators, and Vocational High School Management Model has 8 indicators. There are 52 indicators in total. See Table 1.

Table 1. Outer loading results

Construct	Number of indicators	Lowest loading	Highest loading	Lowest indicator
Vocational School Performance	12	0.646	0.896	KSS12
Academic-Industrial Management	11	0.567	0.833	MAI11
DUDI Partnership Management	7	0.740	0.845	MKD7
Continuous Quality Management	7	0.775	0.897	MMB4
Human Resource Management	7	0.667	0.851	MSD3
Vocational School Management Model	8	0.628	0.806	EIM3

Several indicators were below 0.70, particularly MAI11=0.567, MAI6=0.620, MAI7=0.618, MSD3=0.667, EIM3=0.628, and KSS12=0.646. However, the aggregate construct still had an AVE above 0.50 and adequate reliability. Therefore, indicator removal is not automatically necessary. Removal is only worth considering if there is theoretical justification, the indicator is substantively problematic, and the removal improves the quality of the construct without compromising content validity. Indicator interpretation should remain linked to the construct definition. Indicators with

loadings of 0.60 to 0.70 can still be retained in exploratory research if the construct's reliability and AVE remain adequate. In this research dataset, retaining moderately loaded indicators can help maintain conceptual scope, especially when each indicator represents a different dimension of school management practice.

Internal Reliability and Convergent Validity

All Cronbach's alpha values ranged from 0.870 to 0.946. Rho_A ranged from 0.881 to 0.949, while composite reliability rho_C ranged from 0.897 to 0.953. All AVE values ranged from 0.501 to 0.699. Overall, these results met the criteria for internal reliability and convergent validity. See Table 2.

Table 2. Internal reliability and convergent validity

Construct	Cronbach's α	rho_A	rho_C	AVE
Academic-Industrial Management	0.898	0.901	0.916	0.501
DUDI Partnership Management	0.910	0.911	0.928	0.649
Continuous Quality Management	0.928	0.930	0.942	0.699
Human Resource Management	0.875	0.882	0.904	0.575
Vocational School Management Model	0.870	0.886	0.897	0.523
Vocational School Performance	0.946	0.949	0.953	0.631

Vocational High School performance has a rho_C of 0.953, very close to 0.95. This very high value should be interpreted in conjunction with the indicator, as excessively high reliability can sometimes indicate item redundancy. However, this value is not sufficient to conclude that there is redundancy. An examination of the indicator content is still necessary.

The AVE for Academic-Industrial Management of 0.501 is the lowest value and only slightly above the 0.50 threshold. This indicates that the construct still explains slightly more than half of the variance in its indicators. The construct still meets the convergence criteria, but indicators with low loadings need to be reviewed in further research.

R^2 and f^2: Explanatory Power of the Model

The SMK Management Model has an R^2 of 0.714 and an adjusted R^2 of 0.689. This means that approximately 71.4% of the variance in the SMK Management Model construct is explained by the four predictor constructs in the model, while after adjusting for the number of predictors, the value is 68.9%. SMK performance has an R^2 of 0.992 and an adjusted R^2 of 0.991, which is very high. See Table 3.

Table 3. R^2 and f^2 calculation results

Endogenous constructs	R^2	R^2 adjusted
Vocational School Management Model	0.714	0.689
Vocational School Performance	0.992	0.991

The R^2 of SMK performance approaching 1 should be interpreted cautiously because it simultaneously contains a high HTMT and a high structural VIF. A high R^2 does not automatically mean the model is free from measurement issues or collinearity. In PLS-SEM research, apparent power should be interpreted in conjunction with the quality of the measurement model, the structural model, and its predictive ability. See Table 4.

Table 4. f^2 calculation results

Track	f^2	Interpretation

Academic-Industrial Management → Vocational High School Management Model	0.0956	Small
DUDI Partnership Management → SMK Management Model	0.2787	Currently
Sustainable Quality Management → SMK Management Model	0.0551	Small
Human Resource Management → SMK Management Model	0.1406	Small
Vocational School Management Model → Vocational School Performance	0.3641	Big
Academic-Industrial Management → Vocational High School Performance	0.0000	Very small
DUDI Partnership Management → Vocational High School Performance	2.9255	Big
Sustainable Quality Management → Vocational High School Performance	8.6823	Big
Human Resource Management → Vocational High School Performance	0.2065	Currently

The largest f^2 in the model is Sustainable Quality → Vocational High School Performance at 8.683 and DUDI Partnership → Vocational High School Performance at 2.926. These values are very large according to Cohen's rule of thumb. However, because the VIF of both paths is also high, the large effect sizes need to be examined alongside collinearity to avoid naive interpretation.

Results of the Direct Path Hypothesis Calculation

Statistically, seven of the nine direct paths were significant at α=5%. The two insignificant paths were Academic-Industrial Management → Vocational High School Performance (β=-0.001; p=0.981) and Sustainable Quality Management → Vocational High School Management Model (β=-0.285; p=0.165). See Table 5.

Table 5. Calculation of the Direct Path Hypothesis

Track	β (O)	STDEV	t	p	Decision α=.05
Academic-Industrial Management → Vocational High School Performance	-0.001	0.025	0.024	0.981	Not significant
Academic-Industrial Management → Vocational High School Management Model	0.215	0.108	1,995	0.046	Significant
DUDI Partnership Management → Vocational High School Performance	0.426	0.039	11,055	<0.001	Significant
DUDI Partnership Management → SMK Management Model	0.687	0.213	3,226	0.001	Significant
Sustainable Quality Management → Vocational High School Performance	0.621	0.030	20,479	<0.001	Significant
Sustainable Quality Management → SMK Management Model	-0.285	0.205	1,388	0.165	Not significant
Human Resource Management → Vocational High School Performance	0.067	0.026	2,548	0.011	Significant
Human Resource Management → SMK Management Model	0.307	0.122	2,514	0.012	Significant
Vocational School Management Model → Vocational School Performance	-0.102	0.029	3,461	<0.001	Significant

The path from Vocational High School Management Model to Vocational High School Performance is significant with β=-0.102, t=3.461, p<0.001. The negative sign indicates that, within the model specification and analyzed data, an increase in the Vocational High School Management

Model construct score correlates with a decrease in the Vocational High School Performance score after other predictors are controlled. This is a statistical result that needs to be explained theoretically and should not be transformed into a causal claim without a supporting research design.

Hypothesis Testing H1–H7

Since the labels H1–H7 are not written in the SmartPLS output, the following hypotheses are mapped to the seven focal paths representing the model's core relationships. The paths Academic-Industry → Vocational High School Performance and Human Resources → Vocational High School Performance, which are also available in the output, are still analyzed as additional structural paths. See Table 6.

Table 6. Testing of Hypotheses H1–H7

Hypothesis	Connection	β	t	p	Decision
H1	Academic-Industrial Management → Vocational High School Management Model	0.215	1,995	0.046	Statistically supported
H2	DUDI Partnership Management → SMK Management Model	0.687	3,226	0.001	Statistically supported
H3	Sustainable Quality Management → SMK Management Model	-0.285	1,388	0.165	Not statistically supported
H4	Human Resource Management → SMK Management Model	0.307	2,514	0.012	Statistically supported
H5	Vocational School Management Model → Vocational School Performance	-0.102	3,461	<0.001	Statistically supported
H6	DUDI Partnership Management → Vocational High School Performance	0.426	11,055	<0.001	Statistically supported
H7	Sustainable Quality Management → Vocational High School Performance	0.621	20,479	<0.001	Statistically supported

H1 indicates a positive and significant relationship. H2 is also positive and significant. H3 is negative but not significant. H4 is positive and significant. H5 is significant but negative. H6 and H7 are positive and significant. This mapping is operational for reporting purposes because the hypothesis labels are not stored in the SmartPLS output.

In aggregate, the pattern of results reveals three important findings. First, MKD is a strong predictor of both the SMK Management Model and SMK Performance. Second, MMB has the largest direct effect on SMK Performance, but does not show a significant effect on the SMK Management Model. Third, the path from SMK Management Model → SMK Performance is negative, although significant. This third finding is the most critical because it is inconsistent with the conceptual direction of the model and should be read as a methodological signal that requires further audit, not as evidence that a better management model substantively reduces school performance.

Before discussing the relationships between constructs, measurement quality needs to be established as a foundation for interpretation. All constructs have Cronbach's alpha between 0.870 and 0.946, composite reliability between 0.897 and 0.953, and AVE between 0.501 and 0.699. In general, these figures indicate internal consistency and the construct's ability to adequately explain indicator variance. Hair et al. (2019) identified composite reliability and AVE as critical components in evaluating reflective measurement models.

However, discriminant validity is not entirely convincing. HTMT reached 1.020 for MKD–SMK Performance, 1.045 for MMB–SMK Performance, and 0.964 for MMB–MKD. These values indicate that some constructs may not be sufficiently distinct empirically. Henseler et al. (2015) emphasized that HTMT can identify discriminant validity issues not apparent through Fornell-Larcker. In this study, the high HTMT between MKD and SMK Performance and MMB and SMK Performance may occur because the partnership and quality indicators may capture aspects that are already practically part of respondents' perceptions of school performance.

The substantive implication is that the coefficients MKD → SMK Performance and MMB → SMK Performance need to be read as empirical relationships in the model being estimated, not as evidence that the two constructs are truly completely independent of the SMK Performance construct. In other words, the magnitude of the coefficients can be influenced by the conceptual and empirical closeness between the constructs.

Another issue arises in the indicator VIF, for example, KSS1 = 81.822, KSS7 = 86.938, MAI3 = 30.998, and MAI5 = 26.602. Very high values indicate possible indicator redundancy, very similar response patterns, or specification issues. At the structural level, VIF is also high in MKD → SMK Performance (7.581), MMB → SMK Performance (5.439), MKD → SMK Management Model (5.929), and MMB → SMK Management Model (5.155). Hair et al. (2019) places collinearity checks as an important part before interpreting path coefficients.

Thus, the statistical strength of some paths should not be separated from the context of the measurement model. These findings actually indicate that the research has identified a strong pattern of relationships, but the conceptual model still needs to be refined to more clearly distinguish substantively adjacent constructs.

Indirect Effects and Mediating Mechanisms

Indirect effect $X \rightarrow M \rightarrow Y = \beta(X \rightarrow M) \times \beta(M \rightarrow Y)$

Calculation example: Academic-Industry → Vocational High School Management Model → Vocational High School Performance = 0.214686 × (-0.102059) ≈ -0.021911. Since p=0.086, the indirect effect is not significant. See table 7.

Table 7. Indirect effects

Indirect effects	β	t	p	Decision
Academic-Industrial Management → Vocational High School Management Model → Vocational High School Performance	-0.022	1,717	0.086	Not significant
DUDI Partnership Management → Vocational High School Management Model → Vocational High School Performance	-0.070	1,981	0.048	Significant
Sustainable Quality Management → Vocational High School Management Model → Vocational High School Performance	0.029	1,194	0.233	Not significant
Human Resource Management → Vocational High School Management Model → Vocational High School Performance	-0.031	2,061	0.039	Significant

DUDI partnerships produce an indirect effect of -0.0701 with p=0.048. HR produces an indirect effect of -0.0314 with p=0.039. Sustainable Quality produces an indirect effect of 0.0291 with p=0.233. Since the direct effect of DUDI and HR partnerships is positive while the indirect effect is negative, the two mechanisms are not in the same direction.

Model Fit Evaluation

The SRMR of 0.113 is above the common benchmark of 0.08. SmartPLS explains that model fit plays a more limited role in PLS-SEM than in CB-SEM because PLS does not optimize the same global function. SRMR should be reported but should not be used alone to accept or reject a model. See Table 8.

Table 8. Model Fit Evaluation

Index	Results
SRMR	0.1130423808
d_ULS	17.608883052
d_G	n/a
Chi-square	infinite
NFI	n/a

d_G and NFI are unavailable, while chi-square is recorded as infinite. Therefore, the claim of strong global fit is not supported by this output. The interpretation should focus on the measurement model, structural model, R^2, f^2, VIF, confidence interval, and, if the research objective is predictive, PLSpredict.

The study's SRMR of 0.113 is above the general benchmark of 0.08. d_ULS was recorded at 17.6089, while d_G and NFI were unavailable, and chi-square was recorded as infinite in the output. Hair et al. (2019) emphasized that model fit in PLS-SEM differs from CB-SEM and should not be used as the sole basis for accepting or rejecting a model. However, a relatively high SRMR remains important information that the model specification does not provide an ideal representation of the residuals.

Thus, the research results are more appropriately positioned as initial empirical evidence demonstrating a strong relationship pattern, rather than as a final, fully validated model. Future research should refine the measurement model, test its robustness, and add predictive assessment. Shmueli et al. (2019) developed PLSpredict as an approach to evaluating out-of-sample predictive ability, allowing high R^2 values to be tested to see whether they actually yield strong predictive ability on new data.

In the context of this research, the use of PLSpredict will be crucial. An R^2 of 0.992 may seem impressive, but a more substantive question is whether the model is capable of predicting SMK Performance indicators from observations not used for estimation. If predictive performance is weak, then a high R^2 likely reflects sample characteristics and shared variance rather than predictive generalization.

Discussion of H1–H7 from the Perspective of Educational Management

H1, Academic-Industrial Management → Vocational High School Management Model, obtained β=0.215, t=1.995, p=0.046. This result indicates a positive relationship that is statistically significant at 5%.

H2, DUDI Partnership Management → SMK Management Model, obtained β=0.687, t=3.226, p=0.001. Partnership with the world of work is a relevant component in the transformation of SMK governance. The government's SMK revitalization policy also emphasizes strengthening partnerships with the world of work.

H3, Sustainable Quality Management → SMK Management Model, has β=-0.285 and p=0.165. The negative direction cannot be treated as evidence of a relationship because the confidence interval includes zero.

H4, Human Resource Management → Vocational High School Management Model, has β=0.307, t=2.514, p=0.012. Human Resource Management shows a positive relationship in the model.

H5, SMK Management Model → SMK Performance, has β=-0.102, t=3.461, p<0.001. Significant negative coefficients should be reported as is and verified through coding, scale direction, HTMT, VIF, and possible suppression.

H6, DUDI Partnership → SMK Performance, has β=0.426, t=11.055, p<0.001. Recent Indonesian vocational education studies also report a relationship between industry partnerships and school or graduate outcomes, although the construct and design are different.

H7, Sustainable Quality → Vocational High School Performance, has β=0.621, t=20.479, p<0.001. This relationship is large, but HTMT=1.045 and VIF=5.439 require cautious interpretation.

Additional Structural Path

Academic-Industry → Vocational High School performance is practically close to zero. The total effect is -0.023 due to a small negative indirect effect. Human Resources → Vocational High School performance is positive and significant, but the indirect effect is negative, so the total effect drops to 0.036. See Table 9.

Table 9. Additional Structural Pathways

Track	β	t	p	Conclusion
Academic-Industrial Management → Vocational High School Performance	-0.001	0.024	0.981	Not significant
Human Resource Management → Vocational High School Performance	0.067	2,548	0.011	Significant positive

Hypothesis H1: Academic-Industrial Management → Vocational High School Management Model

H1 obtained a path coefficient of β = 0.215, t = 1.995, and p = 0.046. With a significance level of 5%, the relationship is statistically significant and positive. The 95% confidence interval is between 0.003 and 0.441, thus not including zero. Empirically, improving the quality of academic management connected to industrial needs is related to improving the quality of the SMK Management Model.

This finding can be understood through the characteristics of vocational education, which demands alignment between the learning process and the needs of the workplace. In the context of vocational high schools (SMK), academic management involves not only curriculum administration but also how the curriculum, learning practices, teacher competencies, practical facilities, certification, and industry experience are coherently structured. Therefore, MAI functions as a mechanism that translates the external demands of the workplace into internal school processes.

The β value of 0.215 indicates that its contribution is relatively smaller compared to the MKD → SMK Management Model. This finding does not imply that academic-industry relationships are unimportant. Rather, the results may indicate that the influence of academic-industry relationships on management models occurs more gradually and requires organizational support and external partnerships. In the school system, curriculum strengthening and industrial learning do not automatically change governance without managerial authority, cross-unit coordination, and resource capacity.

These results should also be interpreted in conjunction with the insignificant direct MAI → SMK Performance pathway (β around –0.001; confidence interval –0.035 to 0.062). This means that, in these data, academic-industrial governance appears to be more closely linked to the formation of a management system than to direct changes in school performance. Conceptually, this pattern is

consistent with the view that school change often operates through organizational and leadership mechanisms before being reflected in final outcomes. The school leadership literature also positions organizational processes as a crucial mechanism linking managerial actions to school improvement (Leithwood et al., 2020).

Hypothesis H2: DUDI Partnership Management → SMK Management Model

H2 yields β = 0.687, t = 3.226, and p = 0.001. The 95% confidence interval of 0.267 to 1.106 does not include zero. This is one of the strongest relationships in the model explaining the SMK Management Model. Substantively, these results indicate that partnership management with the business and industrial worlds has a strategic position in the formation of school management models.

In vocational education, partnerships are not merely external activities such as MoUs or industry visits. Managerially managed partnerships can influence curriculum, teaching factories, fieldwork practices, teacher internships, certification, facility procurement, and competency alignment. Pillay et al.'s (2014) study of industry–school partnerships showed that partnership effectiveness depends heavily on implementation principles and strategic support, not just the existence of formal relationships. The findings of this study reinforce this interpretation because the MKD has a significant relationship with the constructs of the SMK Management Model.

However, the results also show a VIF of MKD → SMK Management Model of 5.929 and a VIF of 0.853 for the SMK Management Model–MKD. This suggests that the strength of the relationship should be interpreted with caution regarding construct overlap and collinearity. In other words, MKD may indeed be a core component of the management model, but this definitional proximity can also inflate the coefficient when both are measured from the same respondent source.

From an educational management perspective, the H2 findings support the development of partnerships as part of the governance system, rather than as an add-on program. Partnership management requires targets, division of responsibilities, monitoring mechanisms, outcome evaluation, and sustainability indicators. Partnership models that rely solely on specific individuals risk becoming unsustainable, while supportive organizational structures and strategies can strengthen their sustainability.

Hypothesis H3: Sustainable Quality Management → SMK Management Model

H3 yields β = –0.285, t = 1.388, and p = 0.165. The 95% confidence interval of –0.671 to 0.142 includes zero. Therefore, the negative direction cannot be interpreted as evidence that continuous quality management improvement decreases the quality of the SMK Management Model. Statistically, the data do not provide sufficient evidence to state a direct effect of MMB on the SMK Management Model.

This result is interesting because MMB actually has a very strong direct influence on SMK Performance in H7. This difference suggests that quality management may work more directly on performance outcomes than through the constructs of the SMK Management Model formulated in the study. Conceptually, quality activities such as evaluation, process control, standard monitoring, continuous improvement, and follow-up can result in performance improvements without first having to change respondents' perceptions of the overall school management model.

It is also possible that the MMB construct and the SMK Management Model are too close in some indicators, while the direct paths of MKD and MAI also influence the estimates. The VIF of MMB → SMK Management Model of 5.155 indicates potential collinearity. Hair et al. (2019) emphasize that interpreting paths involving highly correlated predictors should be done cautiously because coefficients can change due to shared variance.

Thus, H3 provides an important theoretical contribution: sustainable quality does not always function as a direct predictor of the aggregate management construct. Further research is needed to examine whether MMB should be positioned as an internal dimension of the SMK Management Model, as an antecedent, or as a mechanism that directly influences performance.

Hypothesis H4: Human Resource Management → SMK Management Model

H4 yields $\beta = 0.307$, $t = 2.514$, and $p = 0.012$, with a confidence interval of –0.017 to 0.474. Because the interval technically still includes the zero value at the lower bound, the interpretation of the confidence interval needs to be aligned with the p-value and bootstrapping procedure used in the output. Based on the two-sided p-value, the path is significant at 5%, but the closeness of the interval boundaries suggests that its estimate should be treated more cautiously than paths with intervals far from zero.

From a managerial perspective, these results demonstrate that human resource management plays a role in shaping the vocational high school management model. Teachers and educational staff are the primary actors translating school policies into practices for learning, services, evaluation, and relationships with industry. Teacher competency development, task allocation, performance evaluation, professional development, and industry experience can strengthen the model's implementation capacity.

These findings are also consistent with the school leadership literature, which emphasizes that school change is not solely driven by leadership decisions, but also by the professional capacity and organizational conditions that enable change to be implemented. Leithwood et al. (2020) emphasize the importance of leadership practices that build organizational conditions and professional capacity to support school improvement.

Thus, MSD needs to be understood as implementation capacity. A well-designed management model can lose its effectiveness if human resources lack the competence, motivation, coordination, and space to implement it.

Hypothesis H5: Vocational High School Management Model → Vocational High School Performance

H5 yields $\beta = –0.102$, $t = 3.461$, and $p < 0.001$. The 95% confidence interval is between –0.173 and –0.058, so the negative relationship is statistically quite stable in the bootstrapping output. This finding should be reported as it is: there is a significant negative relationship between the SMK Management Model construct and SMK Performance in the model specification used.

However, this negative coefficient should not be directly interpreted as a substantive conclusion that better school management leads to lower school performance. Such an interpretation would be too far-fetched, as the model has collinearity and discriminant validity issues, as well as a very high R^2 for SMK Performance, at 0.992. When multiple predictors are highly correlated and constructs overlap, partial path coefficients can exhibit signs different from the expected bivariate or theoretical relationships.

Methodologically, this pattern can be understood as a possible suppression effect. In a model that simultaneously includes MKD, MMB, MSD, MAI, and the SMK Management Model, the SMK Management Model coefficient represents the partial contribution after the variance shared with other predictors is accounted for. If the SMK Management Model has a high overlap with MKD or MMB, the partial coefficient may change direction. The VIF of SMK Management Model → SMK Performance of 3.501 is not extreme, but the combination of the VIFs of other predictors and the high HTMT requires caution in interpreting the negative sign.

H5 also needs to be reviewed from the construct specification aspect. If the SMK Management Model is conceptually a higher-order construct encompassing academic-industry, partnership,

quality, and human resources, then including this aggregate construct along with its constituent dimensions as predictors of SMK Performance may create redundancy and strong shared variance. Alternative models based on higher-order constructs or more parsimonious mediation models need to be tested. The PLS-SEM literature emphasizes the importance of consistency between the theoretical structure and the way constructs are modeled before substantive conclusions can be drawn (Hair et al., 2019).

Therefore, H5 should be positioned as an important diagnostic finding. A negative value is not a reason to modify the data, but rather a reason to examine indicator coding, scale direction, reverse-coded indicators, operational definitions, construct overlap, and possible suppression. After this audit, alternative models can be compared to determine whether the coefficient direction remains negative.

Hypothesis H6: DUDI Partnership Management → Vocational High School Performance

H6 yielded $\beta = 0.426$, $t = 11.055$, and $p < 0.001$, with a confidence interval of 0.360 to 0.509. This represents a strong and relatively stable positive relationship. Substantively, the results indicate that the quality of school relationship management with the business and industrial worlds is closely related to vocational high school performance.

These findings are strongly grounded in the nature of vocational education. Vocational schools operate in the space between the education system and the labor market. Effective partnerships can provide information on competency needs, provide access to technology and actual work practices, enrich the experiences of teachers and students, and open up school-to-work transition pathways. Pillay et al. (2014) demonstrate that industry-school partnerships require strategic management principles and support to avoid becoming merely symbolic activities.

The H6 findings also align with international findings that vocational education and training play a significant role in school-to-work transitions and employment outcomes. Choi et al. (2019) demonstrated that VET is related to skills patterns and employment outcomes, although their study design and unit of analysis differed from this study. Therefore, the H6 findings should not be interpreted as a direct replication, but rather as contextual support for the importance of the link between vocational education and the world of work.

However, H6 also faces a VIF of 7.581. This indicates that the coefficient's magnitude cannot be separated from the possibility of overlap between MKD and other predictors, particularly MMB and the SMK Management Model. Thus, the H6 finding is statistically robust in the current model, but still requires robustness testing.

Hypothesis H7: Sustainable Quality Management → Vocational High School Performance

H7 yields $\beta = 0.621$, $t = 20.479$, and $p < 0.001$, with a confidence interval of 0.556 to 0.676. This is the largest positive coefficient in the model that is directly directed at SMK Performance. The findings indicate that MMB has a very strong direct relationship with school performance.

Substantively, these results make sense if quality management is understood as a cycle of control and improvement that links standards, implementation, monitoring, evaluation, and follow-up. In school organizations, quality involves not only adherence to standards but also the ability to use evaluation information to improve processes. Therefore, effective quality management can impact performance by improving learning processes, student services, resource management, and achieving school goals.

However, the f^2 value of MMB → SMK Performance of 8.6823 is very large and the R^2 of SMK Performance of 0.992 is also very high. This combination needs to be interpreted critically. The R^2 of 0.992 means that approximately 99.2% of the variation in SMK Performance is explained by the predictors in the model, a very high value for social survey data. When combined with the

HTMT MMB–SMK Performance of 1.045, it is possible that the MMB and SMK Performance indicators capture very close aspects. Therefore, the strength of the H7 relationship may reflect both a large substantive effect and shared measurement variance.

In the context of vocational school management research, the implication is not to diminish the importance of quality, but rather to clarify the construct's boundaries. School performance indicators should represent distinct outcomes from quality practices. For example, quality indicators can focus on monitoring, evaluation, corrective action, and continuous improvement systems, while performance indicators should be more focused on outcomes such as graduate achievement, teacher performance, school productivity, accreditation, stakeholder satisfaction, or external outcomes.

Model Explanatory Power: R^2 and Effect Size f^2

The R^2 value of the SMK Management Model of 0.714 indicates that MAI, MKD, MMB, and MSD together explain 71.4% of the variation in the SMK Management Model. This represents high explanatory power for endogenous constructs in the social model, but it must still be read in the context of the sample of only 50 observations and the presence of collinearity.

The R^2 of 0.992 for SMK Performance indicates exceptionally high explanatory power. Mathematically, the model explains 99.2% of the variation in SMK Performance. However, this figure does not automatically mean the model has been proven perfect. Hair et al. (2019) emphasized that PLS-SEM evaluation must consider more than one indicator of model quality. A high R^2 needs to be combined with discriminant validity, VIF, predictive assessment, and robustness. See Table 10.

Table 10. Model Explanatory Power: R^2 and Effect Size f^2

Track	f^2	Reading
MAI → Vocational High School Management Model	0.0956	Small
MKD → SMK Management Model	0.2787	Currently
MMB → Vocational High School Management Model	0.0551	Small
MSD → Vocational High School Management Model	0.1406	Small–medium
Vocational School Management Model → Vocational School Performance	0.3641	Big
MAI → Vocational High School Performance	0.0000	Does not mean
MKD → Vocational High School Performance	2.9255	Very large
MMB → Vocational High School Performance	8.6823	Very large
MSD → Vocational High School Performance	0.2065	Currently

The f^2 pattern shows that MKD and especially MMB are the main contributors to SMK performance. However, very high f^2 values should be interpreted in conjunction with HTMT and VIF. If the predictor and outcome constructs have very similar indicators, the effect size can be inflated due to measurement overlap. Therefore, effect size results are more appropriate for identifying areas for testing and development rather than directly stating causal magnitude.

Analysis of Indirect Effects and the Role of Vocational High School Management Models

The mediation results show a non-simple pattern. MAI and MMB do not have a significant indirect effect through the SMK Management Model. In contrast, MKD and MSD show significant but negative indirect effects. This pattern is consistent with the negative coefficient of H5. If a predictor has a positive effect on a mediator but the mediator has a negative effect on the outcome, the indirect effect can be negative. See Table 11.

Table 11. Indirect Effects

Indirect effects	β	t	p	Interpretation
MAI → Model → Vocational High School Performance	–0.022	1,717	0.086	Not significant
MKD → Model → SMK Performance	–0.070	1,981	0.048	Significant negative
MMB → Model → Vocational High School Performance	0.029	1,194	0.233	Not significant
MSD → Model → Vocational High School Performance	–0.031	2,061	0.039	Significant negative

For MKD, the a-path is positive and strong (0.687), while the mediator-to-outcome path is negative (-0.102), resulting in a negative indirect effect. For MSD, the positive a-path (0.307) is also combined with a negative mediator path. Statistically, this pattern represents a form of mediation that should be understood as the result of a partial model, not as evidence that partnerships or HR substantially harm school performance.

In further research, the mediation model needs to be retested with bootstrap confidence intervals and a more parsimonious specification. Aguirre-Urreta and Rönkkö (2018) demonstrated the importance of bootstrap-based confidence intervals in PLS inference, suggesting that mediation interpretation should not rely solely on the p-value.

Research Findings in the Perspective of Vocational High School Education Management

Overall, the study yielded a picture that SMK performance in the empirical model is primarily related to two domains, namely DUDI partnerships and sustainable quality. MKD has a positive relationship with both the SMK Management Model and SMK Performance, while MMB has a very strong direct relationship with SMK Performance. MSD is also positively related to the SMK Management Model. MAI shows a positive relationship with the SMK Management Model, but does not show a significant direct influence on SMK Performance.

This pattern reinforces the understanding that vocational school management needs to be viewed as a system that connects internal school processes with the external needs of the workplace. Partnerships provide access to industry demands, quality assurance ensures continuous process improvement, human resources provide implementation capacity, and academic and industrial partnerships translate these needs into learning processes.

However, the H5 results remind us that integrating all domains into a single construct of the SMK Management Model must be approached theoretically and empirically with caution. If the aggregate construct is too closely related to its constituent predictors, including them simultaneously in a single equation can result in suppression and partial coefficients that are difficult to interpret. Therefore, the management model developed in this study should be positioned as promising but still requires validation and refinement.

Theoretically, this study suggests that the SMK Management Model may be more appropriately developed as a higher-order construct integrating the MAI, MKD, MMB, and MSD dimensions. This approach needs to be tested through a higher-order composite or hierarchical model, taking into account theory, indicator specifications, and discriminant validity results. This way, the relationship between management dimensions and performance can be tested more consistently.

Managerial Implications

First, schools need to make DUDI partnerships part of their management architecture, not just a public relations function. Partnership planning needs to be linked to competency needs, curriculum updates, work practices, teacher development, certification, and graduate outcomes.

Second, the quality system needs to be directed towards a cycle of improvement that can be demonstrated through data, not simply by document fulfillment. Third, human resource development must be linked to the competencies required for the implementation of industry- and technology-based learning. Fourth, academic-industry management needs to be strengthened through a coordination mechanism between vice principals, heads of expertise programs, productive teachers, and industry partners. Fifth, schools need to develop a performance dashboard that separates management process indicators from outcome indicators to prevent construct overlap in model evaluations. Sixth, annual evaluations of partnerships, quality, human resources, and performance need to use conceptually distinct but logically connected indicators. The most important implication of H5 is the need for a model audit before using it as a strategic decision-making instrument. School management should not conclude that improving the management model will decrease performance solely based on a negative coefficient. It is more appropriate to verify the coding, indicator structure, and model specifications, then re-examine whether the direction of the relationship changes or remains the same.

Interpretation of the results has several limitations. First, the sample size was only 50 respondents, so the stability of the estimates and generalization to the broader vocational high school population require caution. Second, some HTMT and VIF values indicate construct and collinearity issues. Third, the SRMR of 0.113 indicates that the model's global representation is not optimal. Fourth, the survey data collected from the same respondent source may increase the likelihood of common method variance, although specific tests for common method bias are not fully available in the output on which this chapter is based. Fifth, this study used a survey-based observational design, so PLS-SEM coefficients should be understood as statistical relationships within the model, not experimental causal evidence. Sixth, the hypothesis labels H1–H7 are operational mappings because they are not stored in the SmartPLS output. Seventh, the PLSpredict results are not available in the output used, so out-of-sample predictive power cannot be confirmed.

These limitations do not diminish the value of the research findings. Instead, they provide a clear direction for the next validation stage. The research can be strengthened through larger samples, measurement invariance testing, higher-order constructs, bootstrap confidence intervals, PLS prediction, and integration of quantitative data with FGD results.

The results of the study indicate that the implementation of vocational high school management has a complex relationship pattern with school performance. DUDI Partnership Management is an important predictor of both the SMK Management Model and SMK Performance, while Sustainable Quality Management has the strongest direct relationship with SMK Performance. Academic-Industrial Management and Human Resource Management are positively related to the SMK Management Model. Conversely, Sustainable Quality Management does not show a significant influence on the SMK Management Model. The most methodologically important finding is the negative coefficient on the SMK Management Model → SMK Performance. Because this path is significant but in the opposite conceptual direction, the result should be treated as a finding that requires audit and robustness testing. The high HTMT value, high VIF, and R^2 of SMK Performance of 0.992 provide strong reasons not to interpret the coefficient simply.

Thus, the contribution of this research is not simply to indicate which pathways are significant, but also to reveal that vocational high school management models need to be constructed with clearer construct separation, non-redundant indicators, and structural specifications consistent with theory. In the next stage of development, a more parsimonious and predictively tested model has the potential to provide a stronger basis for vocational high school management decision-making.

CONCLUSION

Based on the results of the PLS-SEM analysis, this study shows that improving the performance of Vocational High Schools (SMK) is a multidimensional phenomenon related to the integration of academic-industrial management, partnerships with the business world and the industrial world, sustainable quality management, and human resource management. Academic-Industrial Management is proven to have a positive and significant effect on the SMK Management Model ($\beta = 0.215$; $p = 0.046$), while DUDI Partnership Management has a positive and significant effect on both the SMK Management Model ($\beta = 0.687$; $p = 0.001$) and SMK Performance ($\beta = 0.426$; $p < 0.001$), and Human Resource Management has a positive effect on the SMK Management Model ($\beta = 0.307$; $p = 0.012$) and SMK Performance ($\beta = 0.067$; $p = 0.011$). Sustainable Quality Management shows a very strong direct influence on SMK Performance ($\beta = 0.621$; $p < 0.001$), but does not have a significant effect on SMK Management Model ($p = 0.165$), while the influence of SMK Management Model on SMK Performance shows a negative and significant coefficient ($\beta = –0.102$; $p < 0.001$), which needs to be understood carefully because there are indications of collinearity, construct overlap, and the possibility of a suppression effect. Overall, the SMK Management Model is able to explain 71.4% of its variance, while SMK Performance has an R^2 of 0.992, but the high R^2 must be interpreted critically because some HTMT and VIF values indicate issues of discriminant validity and collinearity. Thus, the research findings confirm that the performance of vocational schools is more appropriately understood as the result of a management ecosystem that integrates the relationship between schools and the world of work, continuous quality control and improvement, human resource capacity, and academic management that is responsive to industry needs, while also showing that the conceptual model developed still requires refinement and robustness testing before it can be positioned as a generally validated vocational school management model.

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