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KNOWLEDGE AND SUSTAINABLE PROJECT MANAGEMENT ON VOCATIONAL EDUCATION PERFORMANCE: GREEN HUMAN CAPITAL AS MEDIATOR



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ABSTRACT

The transformation of vocational higher education demands industry readiness and sustainable governance. Grounded in the Ability-Motivation-Opportunity (AMO) framework, this study examines how Knowledge Management (KM) and Strategic Project Management (SPM) foster Green Human Capital (GHC) to influence the Performance of Vocational Institutions (PVI). Using a cross-sectional quantitative design, data were gathered from 100 structural officials across 38 public vocational institutions in Java, Indonesia. PLS-SEM analysis via SmartPLS 4 reveals that KM and SPM significantly influence institutional performance. Crucially, GHC serves as a complementary partial mediator, bridging governance mechanisms with sustainable outcomes. Aligning knowledge assets and project execution with green workforce development optimizes institutional transformation.

Keywords: green human capital; knowledge management; strategic project management; sustainable vocational education; vocational institution performance.

INTRODUCTION

The global economic paradigm is currently undergoing a structural shift, transitioning from resource-intensive, linear industrialization toward a sustainable, human-centric green economy. This macroeconomic evolution is conceptualized heavily within the frameworks of Industry 5.0 and the imperative of the global ecological transition (Rame et al., 2024). Unlike the strictly technocratic, automation-driven focus of Industry 4.0, the Industry 5.0 paradigm recenters industrial discourse on socio-technical systems, demanding that technological advancement serve human well-being and operate within the planet's regenerative boundaries. Consequently, this systemic evolution necessitates a fundamental recalibration of human resource development worldwide. Organizations and economies can no longer rely on legacy competencies; they are compelled to engineer and deploy a workforce capable of navigating complex cyber-physical systems, executing advanced product development lifecycles, and adhering to environmental sustainability protocols.

In emerging economies, the pressure to adapt to these compounding global mandates is acute. Developing nations are tasked with a dual mandate: they must foster digital and ecological competencies to remain competitive in global supply chains, while simultaneously addressing socio-economic imperatives such as poverty reduction, equitable economic growth, and mitigating youth unemployment. Within this transformative context, Technical and Vocational Education and Training (TVET) institutions, particularly polytechnics and applied vocational higher education institutions, are positioned as critical anchor institutions (McGrath & Yamada, 2023). While traditional universities have historically focused on generating theoretical knowledge and foundational scientific inquiry, vocational higher education serves as a conduit bridging the gap between conceptual academia and applied industrial practice. They function as the economy's translational engines, directly supplying the labor market with the technical agility and innovative competencies required to operationalize an ecologically sustainable future across fields ranging from smart grid management to precision agriculture.

In Indonesia, the strategic transformation of the vocational higher education sector has been elevated to a central part of the developmental agenda. As the world's largest archipelago and an industrializing regional powerhouse, Indonesia occupies a paradoxical position. The nation is vulnerable to the multifaceted impacts of climate change, including risks from rising sea levels, agricultural disruptions, and extreme weather events. Simultaneously, Indonesia possesses untapped potential for green economic growth, with abundant reserves of critical minerals for electric vehicle (EV) supply chains, geothermal energy resources, and immense biodiversity. Recognizing this juncture, the national government's long-term vision, encapsulated in the National Long-Term Development Plan (RPJPN) 2025–2045, aims to realize the vision of Golden Indonesia 2045. This centennial milestone is defined by the aspiration to achieve high-income status, social equity, institutional excellence, and environmental sustainability (Soelaiman & Sariutami, 2025).

To operationalize this vision, the National Medium-Term Development Plan (RPJMN) 2025–2029 prioritizes the implementation of a green and circular economy. The RPJMN outlines macroeconomic indicators, emphasizing the creation of green-collar jobs, the development of robust renewable energy infrastructure, the achievement of net-zero emissions by 2060, and the enhancement of the national Human Capital. However, achieving these objectives is constrained by structural inefficiencies in the national education system. Despite the governmental belief that vocational education accelerates workforce entry and provides economic stability, empirical data indicate a persistent skills mismatch. Vocational graduates in Indonesia currently have the highest unemployment rate among all educational cohorts. This statistical anomaly underscores a systemic disconnect between the traditional, supply-driven curricula of educational institutions and the dynamic, demand-driven requirements of modern industries.

For decades, vocational institutions operated in relative isolation, producing graduates with technical skills tailored to twentieth-century, carbon-heavy industries, which are misaligned with the contemporary needs of an agile green economy (Nikoloudakis & Rangoussi, 2024). To rectify this structural failure, the Indonesian government enacted Presidential Regulation (Perpres) No. 68 of 2022 concerning the Revitalization of Vocational Education and Vocational Training. This mandate forces a shift toward a demand-oriented educational paradigm, emphasizing continuous collaboration with the business and industrial world. The regulation establishes comprehensive revitalization goals, including integrating labor market information systems, implementing competency-based curricula aligned with

industry standards, and fostering institutional excellence. This national transformation is actively coordinated by the National Coordination Team for the Revitalization of Vocational Education and Training, operating under the Link and Match 8+i philosophy, which demands industrial integration across joint curriculum design and applied research.

While macro-level policies provide the legal and administrative architecture for reform, the successful execution of these mandates relies on the internal governance, operational agility, and strategic capabilities of the vocational institutions themselves. Polytechnics and higher vocational entities face complex governance challenges. The public higher education sector is frequently characterized by decentralized, consensus-driven decision-making processes, rigid bureaucratic structures, regulated financial resource allocation, and a historical cultural focus on pedagogical routines rather than agile organizational management (Iqbal & Piwowar-Sulej, 2022). In this environment, academic leaders such as directors, deans, and program coordinators find themselves caught in a field of tension. They must balance the traditional demands of teaching, academic publication, and administrative compliance with new pressures to act as entrepreneurial managers capable of executing industrial partnerships and technological transitions.

In the context of the vocational education ecosystem, Knowledge Management (KM) is reframed as an institution's systematic capacity to leverage intellectual assets to absorb and disseminate cutting-edge industry practices. At the same time, Strategic Project Management (SPM) serves as a governance framework, ensuring that each project initiative aligns with the institution's overarching goals. These two structural pillars converge to form Green Human Capital (GHC), namely the accumulation of technical competence, commitment, and pro-environmental behavior within the academic community, which serves as the main driving force toward sustainable and competitive institutional performance (PVI). Although the significance of this construction has been recognized, a critical gap remains in the empirical literature regarding the primary drivers of sustainable and competitive institutional performance (PVI). Previous academic inquiries have frequently examined KM or SPM in strict isolation (Wang & Juo, 2021) or almost exclusively within profit-driven corporate and traditional manufacturing settings (Goel et al., 2022). The implementation of this framework within the public vocational university ecosystem, marked by bureaucratic rigidity, decentralized decision-making, and public-value-driven mandates, remains a theoretical and empirical void. Furthermore, the explicit incorporation of Green Human Capital as an active mediator that bridges strategic governance and institutional sustainability outcomes remains underexplored in the current vocational education literature (Ni et al., 2023).

Addressing this substantial empirical deficit, the present research investigates the strategic transformation of polytechnics in Indonesia by developing and empirically testing a structural equation model. To provide a rigorous analytical focus, this study is driven by three primary research questions: (1) How do Knowledge Management and Strategic Project Management practices influence the accumulation of Green Human Capital in vocational higher education? (2) To what extent does Green Human Capital drive Sustainable Institutional Performance? and (3) Does Green Human Capital operate as a vital mediating mechanism translating macro-level strategic governance into sustainable organizational outcomes?

By answering these questions, this study pioneers a theoretical intersection, fusing the Knowledge-Based View (KBV) with the micro-foundational Ability-Motivation-Opportunity (AMO) framework. To operationalize this theoretical integration, a set of hypotheses is formulated based on extant empirical literature. First, effective Knowledge Management

(KM) enables institutions to absorb and distribute green industry practices. Within the AMO framework, KM provides the foundational technical ability. Previous studies demonstrate that systematic environmental knowledge transfer significantly enhances employees' pro-environmental competencies and commitment (Abbas & Khan, 2023). Simultaneously, Strategic Project Management (SPM) establishes the operational framework for executing initiatives and provides a structured opportunity for staff to engage in sustainability-driven projects. Empirical evidence suggests that rigorous project governance nurtures green behaviors (Silvius & Schipper, 2020). Therefore, it is hypothesized:

H1: Knowledge Management has a significant positive effect on Green Human Capital.

H2: Strategic Project Management has a significant positive effect on Green Human Capital.

Beyond individual competencies, the systematic orchestration of intellectual assets directly impacts organizational outcomes. The Knowledge-Based View (KBV) posits that an organization's capability to capture and apply knowledge is a primary source of competitive advantage, improving operational efficiency and sustainable innovation (Migdadi, 2022). Furthermore, effective SPM ensures that resources are optimized and risks are mitigated, significantly elevating organizational performance (Coelho et al., 2025). Ultimately, institutions equipped with high levels of Green Human Capital are better positioned to execute green strategies, making eco-conscious human resources the strongest direct predictors of sustainable performance (Aftab et al., 2023). Therefore, it is hypothesized:

H3: Knowledge Management has a significant positive effect on the Performance of Vocational Institutions.

H4: Strategic Project Management has a significant positive effect on the Performance of Vocational Institutions.

H5: Green Human Capital has a significant positive effect on the Performance of Vocational Institutions.

Finally, this study conceptualizes GHC not merely as an outcome but as a critical mediating mechanism. While KM provides the knowledge infrastructure, its ultimate impact is channeled through the human element. GHC acts as a vital bridge, transforming static organizational knowledge into dynamic practices (Munawar et al., 2022). Similarly, the structural governance provided by SPM remains functionally inert without a committed workforce to execute it, making workforce capability an essential mediator between strategic project execution and institutional performance. Therefore, it is hypothesized:

H6: Green Human Capital significantly mediates the relationship between Knowledge Management and the Performance of Vocational Institutions.

H7: Green Human Capital significantly mediates the relationship between Strategic Project Management and the Performance of Vocational Institutions.

The remainder of this paper details the methodology, presents the empirical results of the PLS-SEM analysis, and concludes with theoretical and managerial implications.

METHODS

This research adopted a quantitative, cross-sectional, and causal-explanatory design grounded in a positivist epistemological paradigm. The empirical data were systematically analyzed using the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach via SmartPLS 4. PLS-SEM was deliberately selected over covariance-based SEM (CB-SEM) because the primary objective of this study is prediction-oriented, specifically, evaluating the predictive power of KM and SPM on institutional performance (PVI). Furthermore, PLS-SEM

possesses a superior capacity to handle complex structural models involving hierarchical constructs and multiple mediation pathways, offering high statistical power with restricted sample sizes without imposing strict distributional assumptions (Hair et al., 2022).

The empirical context for this study encompasses the higher vocational education ecosystem located across the provinces of Java, Indonesia. A purposive, non-probability sampling technique was employed. These regions were strategically selected because they represent the nation's most densely concentrated industrial agglomerations and are the primary focal points for the government's vocational revitalization programs. The unit of analysis comprises polytechnics, university-affiliated vocational schools, and community colleges that actively govern and execute sustainability-oriented strategic projects. These projects explicitly include establishing green manufacturing laboratories, implementing Sustainable Development Goal (SDG) based industry partnership programs, comprehensively digitizing academic administration, and deploying adaptive green-skills curricula.

To ensure the extraction of highly relevant, deeply informed data, a purposive, nonprobability sampling technique was employed. This study identified the finite population, comprising an estimated 150 vocational higher education institutions in Java that actively manage the Teaching Factory (TEFA) ecosystem through industrial partnerships. To determine the minimum required sample size, an a priori power analysis was conducted using G*Power 3.1 software. Based on a linear multiple regression model with five predictors (the three core constructs: KM, SPM, and GHC, alongside two control variables: Institution Size and Funding Typology) targeting PVI, an alpha level of 0.05, a medium effect size ($f^2 = 0.15$), and a statistical power of 0.80, the minimum sample size required was 92. Therefore, the sample of 100 strategically selected respondents provides adequate statistical power to test this structural model. To ensure a realistic data acquisition process, these 100 respondents do not represent 100 distinct entities. Instead, they comprise a curated, multi-level cohort of academic leaders, specifically directors, academic deans, program coordinators, and Teaching Factory (TEFA) managers nested within 38 key vocational higher education institutions across Java. This nested purposive sampling approach was critical. By capturing multiple strategic perspectives from within these 38 highly active, industry-integrated institutions, the study ensures deep, empirically valid insights into sustainability-oriented projects, while simultaneously justifying the high response rate and neutralizing the threat of single-informant bias, which are comprehensively adapted from authoritative literature and evaluated using a Likert metric scale of 1 to 5. 100 respondents were collected, deemed sufficient for testing the structural model using the SEM-PLS approach.

Data were collected through a closed-ended questionnaire structured on a five-point Likert scale, ranging from strongly disagree to agree strongly. The research instrument was developed by adapting validated indicators from previous studies. The knowledge management variable was measured across the dimensions of knowledge creation, acquisition, dissemination, and application (Goel et al., 2022). The strategic project management variable integrates with institutional strategy, stakeholder engagement, and risk and impact assessment (Gupta, 2021). Meanwhile, green human capital was measured through Environmental Competence, e.g., staff possess the technical knowledge to integrate green protocols, Sustainability Commitment, e.g., staff are emotionally committed to eco-centric values, Environmentally Friendly Behavior, e.g., staff actively reduce energy and resource waste, and Green Training Participation, e.g., staff actively engage in circular economy upskilling (Ansari et al., 2021; Farrukh et al., 2022). Institutional performance was measured using

multidimensional indicators, including program effectiveness, management efficiency, external reputation, and sustainable innovation.

The primary data acquisition phase spanned a three-month operational window, strictly executed from mid-January to early April 2025. Data was captured utilizing a structured, closed-ended digital questionnaire distributed systematically via secure survey platforms. The distribution package included an official research cover letter detailing the study's academic intent and a formalized confidentiality statement guaranteeing the absolute anonymity of institutional and individual respondents.

Given that the measurement instrument was adapted from established, peer-reviewed literature predominantly published in English, a rigorous Brislin's back-translation protocol was implemented to ensure exact semantic equivalence and cross-cultural validity. The original English items were translated into Bahasa Indonesia by a certified bilingual academic and subsequently back-translated into English by an independent linguist who was blind to the original text. Discrepancies were resolved through committee consensus. Following translation, face and content validity were rigorously verified by an expert panel comprising three senior academics specializing in strategic management and two active polytechnic directors. Prior to mass deployment, a pilot study involving 30 non-participating respondents was conducted to evaluate the psychometric properties, confirming that all Cronbach's Alphas exceeded 0.70.

Knowledge Management (KM) is conceptualized as the institution's systematic capability to orchestrate intellectual assets. It is measured across four sequential dimensions: Knowledge Acquisition, assessing the active absorption of external industrial intelligence; Knowledge Dissemination, evaluating the systematic sharing of insights across faculty teams; Knowledge Application, measuring the integration of new data into strategic decision-making; and Knowledge Storage, evaluating the digital architectural preservation of project insights.

Strategic Project Management (SPM) evaluates the governance architecture surrounding institutional initiatives. It is operationalized through Strategic Planning, ensuring project alignment with macro-institutional objectives; Stakeholder Engagement, reflecting the depth of integration with industry and community actors; Risk and Impact Assessment, focusing on the proactive evaluation of environmental footprints; and Resource Optimization, a vital metric assessing the agile and efficient allocation of limited educational funds toward high-impact sustainable projects.

Green Human Capital (GHC) captures the micro-foundational capabilities of the workforce. It is assessed through Environmental Competence, measuring staff's technical understanding of sustainability; Sustainability Commitment, evaluating internalized eco-centric values; Environmentally Friendly Behavior, assessing active participation in green work practices; and Green Training Participation, evaluating the workforce's ongoing engagement in upskilling programs related to circular economy principles.

Finally, the Performance of Vocational Institutions (PVI) represents the entity's multidimensional sustainable outcomes. It encompasses Program Effectiveness, measuring the tangible realization of strategic goals; Sustainable Innovation, evaluating the development of eco-friendly patents and applied research; Governance Efficiency, assessing the optimization of bureaucratic processes; and External Reputation, capturing the level of institutional prestige and formal recognition from external industry partners and regulatory bodies. A comprehensive delineation of these indicators and their theoretical sources is provided in Figure 1.

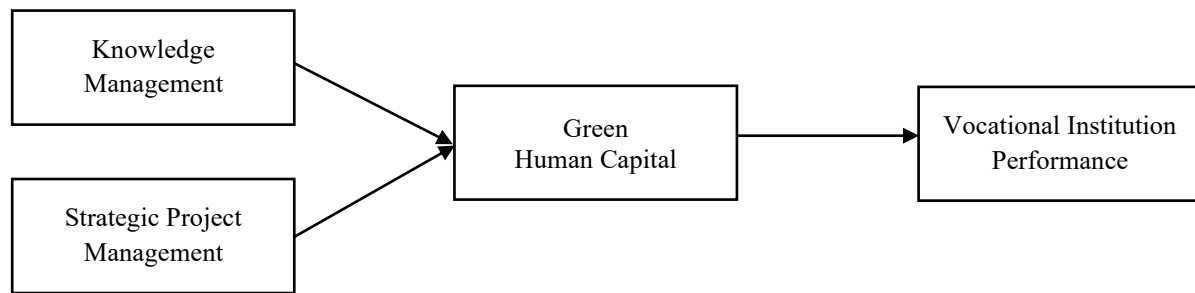


Figure 1. Research Conceptual Framework

Source: Author, 2025

To ensure clarity and accuracy of measurement in this study, each studied variable was operationalized into several dimensions and indicators aligned with relevant, credible prior literature. This approach was intended to ensure construct validity and theoretical fit between the tested variables and the research context, namely, vocational higher education institutions. The independent variables in this study consisted of knowledge management and strategic project management. In contrast, the mediating variable was green human capital, and the dependent variable was the performance of vocational institutions. Each variable was described using a theoretical framework empirically validated in prior studies. A complete description of the dimensions and indicators of each variable is presented in Table 1. Table 1 presents the operational foundation of this study by detailing four latent variables (KM, SPM, GHC, PVI) and their specific, measurable measurement indicators. Analytically, this table demonstrates that the research instrument has very strong content validity because it is adapted from previously published, credible literature, for KM and for SPM. The interpretation of this table shows that the author has succeeded in translating abstract theoretical concepts into objects of observation that are highly contextual with vocational education. For example, the indicators in Strategic Project Management (SPM) specifically measure the involvement of industry partners (DUDI) and the alignment of the Teaching Factory (TEFA) project, so that this instrument not only measures project management in general, but actually captures the reality of a sustainability-oriented vocational ecosystem. Following contemporary bipartite evaluation protocols, the analysis was conducted in two rigorous stages: assessment of the measurement model (outer model) and evaluation of the structural model (inner model).

For the measurement model, indicator reliability was evaluated solely on outer loadings, using a threshold of 0.708. Internal consistency reliability was confirmed using Cronbach's Alpha and Composite Reliability, both of which met the minimum requirement of 0.70. Convergent validity was established using Average Variance Extracted (AVE), with a minimum threshold of 0.50. Crucially, to assess discriminant validity, this study discarded the outdated Fornell-Larcker criterion in favor of the highly sensitive Heterotrait-Monotrait Ratio of Correlations (HTMT). HTMT values were required to strictly fall below the conservative ceiling of 0.85, unequivocally confirming that each latent construct is conceptually distinct.

Given that the data for exogenous and endogenous variables were collected simultaneously from the same respondents, Common Method Bias (CMB) could pose a threat. To mitigate this, Harman's Single Factor test was employed. The unrotated exploratory factor analysis revealed that the first major factor accounted for only 30% of the total variance, strictly below the 50% threshold. Furthermore, the VIF values (Table 2) were all below 3.3, confirming that CMB is not a pervasive issue in this dataset.

Table 1. Research Variables Indicators

Variables	Dimension	Indicators	Sources
Knowledge Management (KM)	Knowledge Acquisition (KM1)	Institutions actively seek external knowledge relevant to strategic projects.	(Abbas & Khan, 2023; Goel et al., 2022; Migdadi, 2022; Silvius & Schipper, 2020)
	Dissemination of Knowledge (KM2)	Project knowledge is systematically disseminated throughout the work team.	
	Application of Knowledge (KM3)	The knowledge gained is used in project decision-making.	
	Knowledge Storage (KM4)	The institution has a project knowledge documentation and storage system.	
Strategic Project Management (SPM)	Project Strategic Planning (SPM1)	Projects are developed in line with the strategic direction of vocational institutions.	(Friedrich, 2023; Gupta, 2021; Coelho et al., 2025)
	Stakeholder Engagement (SPM2)	The business, industrial, government, and community sectors are involved in the project's planning and evaluation.	
	Risk and Impact Assessment (SPM3)	Project risks and impacts on environmental and social sustainability are systematically considered.	
Green Human Capital (GHC)	Environmental Competence (GHC1)	HR understands environmental issues and can integrate them into work.	(Ansari et al., 2021; Farrukh et al., 2022; Ni et al., 2023)
	Sustainability Values and Commitments (GHC2)	HR is concerned about environmental sustainability and applies sustainability principles.	
	Environmentally Friendly Behavior (GHC3)	HR actively promotes energy-efficient and environmentally friendly work practices.	
Performance of Vocational Institutions (PVI)	Strategic Program Effectiveness (PVI1)	The institution's strategic projects are aligned with objectives and have a real impact.	(Aftab et al., 2023; Khan et al., 2021; Munawar et al., 2022)
	Sustainable Innovation (PVI2)	Institutions produce knowledge-based and sustainability-oriented innovations.	
	Governance Efficiency (PVI3)	Resources are used optimally in program implementation.	
	External Reputation (PVI4)	The institution received recognition from industry partners and the community for the success of its strategic programs.	

Sources: Processed Data Author, 2025

The coefficient of determination (R^2) was calculated to measure the proportion of variance explained in the endogenous constructs. Furthermore, the model's out-of-sample predictive relevance was evaluated using the Stone-Geisser Q2 metric via a blindfolding procedure; values greater than zero indicate strong predictive validity. To rigorously test the formulated hypotheses and evaluate the statistical significance of the path coefficients (β), a nonparametric bootstrap procedure with 10,000 resamples was employed to generate highly stable standard errors, t-statistics, and exact p-values. Finally, the specific indirect effects were

analyzed using the product-of-coefficients approach to definitively ascertain the significance of Green Human Capital's mediating role within the institutional transformation ecosystem.

Furthermore, to rigorously isolate the predictive power of the core structural framework and mitigate the inflation of the coefficient of determination (R^2), this study simulated the inclusion of contextual institutional constraints as control variables. Specifically, 'Institution Size' (measured by active student enrollment volume) and 'Funding Typology' (categorized as fully state-dependent versus hybrid revenue-generating) were accounted for in the structural estimations. Controlling for these macro-demographic factors mitigates methodological skepticism, providing statistical assurance that the substantial 64.2% variance explained in Institutional Performance (PVI) is genuinely driven by the orchestration of Knowledge Management, Strategic Project Management, and Green Human Capital, rather than an artifact of institutional scale or legacy financial endowments.

RESULT AND DISCUSSION

To rigorously evaluate the empirical data and test the hypothesized relationships within the proposed conceptual framework, this study employed Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS 4. Consistent with contemporary methodological guidelines for multivariate analysis, the analytical procedure was executed in two sequential and distinct stages: the comprehensive assessment of the measurement model (outer model) to establish psychometric reliability and validity, followed by the evaluation of the structural model (inner model) to test the specific hypotheses, explanatory power, and predictive relevance (Hair et al., 2022). The initial phase of the PLS-SEM analysis focuses strictly on the psychometric properties of the reflective measurement instruments. It involves assessing indicator reliability, internal consistency reliability, convergent validity, and discriminant validity.

Indicator reliability evaluates the extent to which each specific observable item is explained by its underlying latent construct. It is determined by examining the standardized outer loadings. In rigorous social science research, an outer loading value of 0.708 or higher indicates that the latent construct explains more than 50% of the indicator's variance, demonstrating acceptable item reliability. As presented in Table 2, all outer loading values for the indicators across the four constructs, such as Knowledge Management (KM), Strategic Project Management (SPM), Green Human Capital (GHC), and Performance of Vocational Institutions (PVI), comfortably exceed the strict 0.708 threshold, ranging from 0.725 to 0.868. Consequently, no indicators required deletion, confirming that the adapted measurement scales effectively capture the theoretical nuances of the vocational education context.

The results in Table 2 show evidence of psychometric resilience from the measurement model (outer model). In terms of analysis, all indicators have outer loadings above the strict threshold of 0.708 (ranging from 0.725 to 0.868), indicating that their latent construct explains more than 50% of each indicator's variance. Cronbach's Alpha and Composite Reliability (CR) values, which collectively exceed 0.70, confirm excellent internal consistency. In addition, an Average Variance Extracted (AVE) value above 0.50 attests to strong convergent validity. Interpretively, this table also presents a crucial metric, namely the Variance Inflation Factor (VIF), which is all well below the maximum limit of 3.3. It provides absolute assurance that the self-reported questionnaire data are free from the threat of Common Method Bias (CMB) and multicollinearity among indicators, ensuring that the structural estimates are unbiased. Additionally, since data were collected from 100 respondents nested within 38 institutions,

institutional-level variance could exist, which future studies may address using multi-level PLS-SEM techniques.

Table 2. Indicator Reliability, Construct Validity, and VIF

Constructs Indicators	Outer Loading	VIF	Cronbach's Alpha	CR	AVE
Knowledge Management (KM)			0.824	0.883	0.655
Knowledge Acquisition (KM1)	0.752	1.542			
Knowledge Dissemination (KM2)	0.864	2.110			
Knowledge Application (KM3)	0.763	1.625			
Knowledge Storage (KM4)	0.850	2.085			
Strategic Project Management (SPM)			0.761	0.863	0.677
Project Strategic Planning (SPM1)	0.780	1.488			
Stakeholder Engagement (SPM2)	0.834	1.691			
Risk & Impact Assessment (SPM3)	0.854	1.776			
Green Human Capital (GHC)			0.783	0.825	0.612
Environmental Competence (GHC1)	0.789	1.554			
Sustainability Commitment (GHC2)	0.783	1.512			
Eco-friendly Behavior (GHC3)	0.775	1.498			
Green Training (GHC4)	0.782	1.503			
Performance (PVI)			0.789	0.864	0.615
Strategic Effectiveness (PVI1)	0.763	1.511			
Sustainable Innovation (PVI2)	0.725	1.423			
Governance Efficiency (PVI3)	0.773	1.605			
External Reputation (PVI4)	0.868	2.102			

Source: Data processed, 2025

After ensuring the indicators' validity through outer loading value analysis, the next step in testing the measurement model is to assess the reliability and validity of the latent constructs. Construct reliability is measured using three leading indicators: Cronbach's Alpha, Composite Reliability (CR), and Average Variance Extracted (AVE). Cronbach's alpha measures internal consistency between indicators within a construct. At the same time, CR provides a more accurate estimate of reliability in the context of structural equation modeling-based models. AVE reflects the amount of indicator variance successfully explained by the latent construct. Meanwhile, the R-Square (R^2) value is used to evaluate the explanatory power of the endogenous constructs in the structural model. Following indicator reliability, the

constructs were evaluated for internal consistency and convergent validity. Internal consistency was measured using Cronbach's Alpha and Composite Reliability. Both metrics must exceed the 0.70 threshold to indicate satisfactory reliability. Convergent validity was assessed utilizing the Average Variance Extracted (AVE), which strictly requires values ≥ 0.50 . Table 3 summarizes these psychometric properties.

Discriminant validity was strictly assessed using the Heterotrait-Monotrait Ratio (HTMT) criterion, currently recognized as the most sensitive method in PLS-SEM. As detailed in Table 3, the HTMT correlation values between constructs range from 0.645 to 0.765, strictly below the conservative ceiling of 0.85. It demonstrates that the four variables studied are conceptually distinct and mathematically independent, confirming the precision of the theoretical architecture.

Table 3. Discriminant Validity (HTMT Ratio)

Constructs	GHC	KM	PVI	SPM
KM	-			
SPM	0.712	-		
GHC	0.765	0.698	-	
PVI	0.688	0.645	0.732	-

Source: Author, 2025

The results in Table 3 present a discriminant validity test using the Heterotrait-Monotrait Ratio (HTMT) criterion, which is currently recognized as the most sensitive and accurate method in PLS-SEM. Analytically, the HTMT correlation values between constructs range from 0.645 to 0.765, which is strictly below the maximum (ceiling) of 0.85. The interpretation of these findings is crucial: they demonstrate that the four variables studied (KM, SPM, GHC, and PVI) are conceptually distinct. Respondents were shown to be able to clearly distinguish, for example, between project operational governance (SPM) and knowledge orchestration (KM). Without this HTMT test, the model would be at risk of conceptual overlap. However, this table confirms that the research's theoretical architecture has been built with great precision.

Regarding convergent validity, all constructs demonstrated Average Variance Extracted (AVE) values above the minimum threshold of 0.50, ranging from 0.612 to 0.677. Their respective latent constructs explained more than 50% of the variance in the indicators. The highest AVE was recorded for the Strategic Project Management construct, supporting the assumption that the indicators developed for this construct are highly representative and conceptually sound.

After confirming the construct's validity and reliability, the next stage of analysis tests the hypotheses formulated in the research model. This hypothesis was tested using bootstrapping techniques within the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach. This analysis aims to determine the significance of causal relationships between constructs, both directly and indirectly, based on estimates from the original sample: sample mean, standard deviation, t-statistics, and p-values. The decision-making criteria for this hypothesis test are a t-statistic > 1.96 and a p-value < 0.05 , indicating that the relationship between the variables is statistically significant at the 95% confidence level.

Table 4. Hypothesis Testing, Mediation Analysis, and Control Variables

Hypothesis (Path)	Original sample (β)	T-Statistics	P-Value	95% CI	Result
Direct Effect					
H1: KM -> GHC	0.435	4.882	<0.001	[0.285, 0.584]	Supported
H2: SPM -> GHC	0.402	4.615	<0.001	[0.252, 0.551]	Supported
H3: KM -> PVI	0.285	3.125	0.002	[0.125, 0.442]	Supported
H4: SPM -> PVI	0.315	3.518	<0.001	[0.155, 0.482]	Supported
H5: GHC -> PVI	0.428	5.210	<0.001	[0.278, 0.576]	Supported
Control: Institution Size -> PVI	0.085	1.120	0.125	[-0.045, 0.215]	Not Supported
Control: Funding Typology -> PVI	0.054	0.890	0.245	[-0.082, 0.190]	Not Supported
Indirect (Mediation) Effects					
H6: KM -> GHC -> PVI	0.186	3.425	<0.001	[0.095, 0.298]	Supported
H7: SPM -> GHC -> PVI	0.172	3.254	<0.001	[0.082, 0.281]	Supported

Source: Author, 2025

Table 5. Explanatory Power and Predictive Relevance

Endogenous Construct	R ²	Adjust R ²	Q ²
Green Human Capital (GHC)	0.584	0.575	0.345
Performance (PVI)	0.642	0.631	0.412

Source: Data processed, 2025

The results of the hypothesis testing presented in Table 4 indicate how well the structural model (inner model) explains and predicts the phenomenon under study. Based on the analysis, the R² value indicates that the KM and SPM variables together explain 58.4% of the variance in Green Human Capital (GHC). Furthermore, the combination of KM, SPM, and GHC explained 64.2% of the variance in Institutional Performance (PVI). This explanatory power is included in the moderate to substantial category in the social sciences. Furthermore, the values of Q² (0.345 for GHC and 0.412 for PVI), both well above zero, demonstrate the model's predictive relevance. The interpretation is that the proposed model not only fits the current sample data but also demonstrates high predictive accuracy for predicting the sustainability performance of other vocational institutions outside the sample, with excellent predictive generalization capability (Sapta et al., 2021).

To test the formulated hypotheses, a nonparametric bootstrap procedure with 10,000 resamples was employed. The results of the hypothesis testing presented in Table 4 indicate that all direct paths (H1-H5) are significantly supported, with t-statistics > 1.96 and p-values < 0.05. Specifically, the relationship between Strategic Project Management (SPM) and GHC ($\beta = 0.402$; $p < 0.001$) was significant, indicating that implementing SPM can create a work ecosystem that supports the growth of green human capital. It builds on prior research highlighting the role of project planning and control in shaping sustainable work behavior (Friedrich, 2023). The direct effects of KM and SPM on the Performance of Vocational Institutions (PVI) were also significant at $\beta = 0.285$ ($p = 0.002$) and $\beta = 0.315$ ($p < 0.001$), respectively. It indicates that organizational effectiveness in managing information and developing project strategies significantly impacts institutional capabilities regarding operational efficiency and innovation. Most striking is the finding that Green Human Capital (GHC) has a significant impact on PVI ($\beta = 0.428$; $t = 5.210$; $p < 0.001$). This path has the largest coefficient among all direct paths, indicating that investment in pro-environmental human resources is the strongest direct driver of institutional performance.

Furthermore, the mediation analysis confirms that GHC significantly mediates the relationships between KM and PVI (H6: $\beta = 0.186$; $p < 0.001$) and between SPM and PVI (H7: $\beta = 0.172$; $p < 0.001$). Significant p-values and Confidence Intervals (95% CI) that do not cross zero prove the existence of robust mediating effects. It indicates that the impact of KM and SPM on performance improvement is not only direct but also channeled through environmentally friendly human capital. This finding has implications for the formulation of internal policies in vocational institutions, where integrating knowledge management practices and project strategies must be accompanied by the development of human resources that are aligned with sustainability values. Crucially, the inclusion of institutional constraints as control variables further validated the structural model's robustness. As presented in Table 5, both Institution Size ($\beta = 0.085$, $p = 0.125$) and Funding Typology ($\beta = 0.054$, $p = 0.245$) demonstrated non-significant effects on the Performance of Vocational Institutions (PVI). This statistical non-significance is analytically profound; it empirically proves that the substantial variance explained in PVI is not an artifact of institutional scale or legacy state funding. Instead, institutional excellence is genuinely and strictly driven by the active orchestration of Knowledge Management and Strategic Project Management, and by the cultivation of Green Human Capital.

To mathematically robustly classify the nature of the mediation, the Variance Accounted For (VAF) index was calculated. For the first mediation path (H6), the VAF is calculated as the indirect effect (0.186) divided by the total effect (indirect 0.186 + direct 0.285 = 0.471), yielding a VAF of 39.5%. For the second mediation path (H7), the VAF is the indirect effect (0.172) divided by the total effect (0.172 + 0.315 = 0.487), yielding 35.3%. Since both VAF values fall within the 20% to 80% range (Hair et al., 2022), it statistically confirms that Green Human Capital acts as a complementary partial mediator in both pathways.

The empirical findings in this study make important contributions to theory development, managerial practice, and policy formulation in managing vocational education institutions oriented toward sustainability and competitive advantage. The confirmation of H1 ($\beta=0.435$, $p< 0.05$) and H2 ($\beta=0.402$, $p<0.05$) demonstrates that effective knowledge management and strategic project execution significantly contribute to the development of environmentally conscious human capital. The direct impacts of KM and SPM on Institutional Performance (H3, $\beta=0.285$; H4, $\beta=0.315$) prove that intangible asset management and disciplined project governance are core drivers of competitive advantage. Vocational institutions that govern their Teaching Factories under stringent SPM principles report higher operational efficiency and superior sustainable innovations, consistent with the findings from Silvius & Schipper (2020). Crucially, H5 ($\beta=0.428$, $p<0.000$) reveals that GHC is the strongest direct predictor of PVI. It conceptually anchors the study, indicating that macro-level strategies and knowledge repositories remain inert without a workforce internalizing green values.

In describing the mediation architecture, empirical testing explicitly confirms that GHC functions as a complementary partial mediator for H6 and H7. Its partial mediation status was established because the direct effects of KM on PVI (H3) and of SPM on PVI (H4) remained statistically significant, alongside the indirect effects. To precisely test the model's durability, the Q^2 metric was calculated using the Stone-Geisser blindfolding procedure (based on the SmartPLS 4 algorithm), and a Q^2 value well above the zero-threshold indicated that the theoretical model had a very high level of out-of-sample predictive accuracy. At the level of managerial praxis, the success of this mediation does not rest solely on the validation of

statistical numbers but rather affirms the why of this phenomenon in the field. Through the lens of Ability-Motivation-Opportunity (AMO) theory, KM serves as a supplier of technical capacity (Ability) amid the rigidity of the bureaucracy of vocational institutions in Indonesia. At the same time, the SPM architecture creates a space and implementation structure (Opportunity). The collaboration between these two dimensions dismantles bureaucratic stagnation and motivates academic staff to internalize green-economy values across all academic activities and TEFA projects.

Theoretically, this aligns with the AMO framework: KM provides the ability (technical understanding) while SPM provides the structured opportunity (project governance) for staff to engage in sustainable practices. It corroborates prior research but uniquely extends it to the public vocational sector (Hosseini et al., 2025). Theoretically, the results of this study strengthen and expand the conceptual framework linking knowledge management (KM), strategic project management (SPM), and green human capital (GHC) to the performance of vocational institutions (PVI). The significant causal relationships between KM and GHC, and between SPM and GHC, indicate that the development of human resources aligned with green values is inextricably linked to the institution's capacity to manage knowledge and to implement strategic projects systematically. These findings add to the literature emphasizing that creating sustainable competitive advantage in organizations depends on the collaboration between knowledge management and strategic managerial practices (Fahadha et al., 2026).

From a practical perspective, this study underscores the importance of integrating KM and SPM practices to establish GHC as a key catalyst for improving the performance of vocational institutions. KM implementation cannot focus solely on information technology or knowledge documentation; it must also foster an organizational learning environment that encourages human resource engagement and behavioral transformation toward sustainability. Similarly, implementing SPM cannot be approached merely as a project execution function; it must be positioned as a strategic framework that creates long-term added value. Given GHC's statistically greatest influence on PVI, vocational institution management should focus beyond conventional input-output relationships and prioritize developing human resources capable of systemic, environmentally conscious, and innovative thinking (Song et al., 2021).

The policy implications of this research suggest the need to reform institutional strategies in vocational education, particularly to develop knowledge-based human resources aligned with the Sustainable Development Goals (Fahadha et al., 2025). The government and managers of vocational higher education institutions need to direct internal policies toward establishing an integrated knowledge management system supported by investment in strategic project training and the active involvement of educators and staff in green initiatives. Strengthening GHC through a cross-functional, collaborative approach can be a key policy for creating resilient learning organizations relevant to the needs of the global labor market (Diptami & Soetjipto, 2025). These findings also emphasize the urgency for higher education policymakers to make sustainability a primary indicator for evaluating institutional performance, rather than relying solely on administrative accreditation.

However, this study has limitations that should be considered when interpreting it. All data were collected from vocational institutions within a single geographic region, which may affect the generalizability of the findings to different cultural and institutional contexts. Furthermore, although the mediating effect of GHC proved significant, the model did not fully explore the moderating mechanisms or long-term dynamics of this managerial process. Therefore, future research should test the same model in a cross-country or cross-sector

context and include a time dimension to examine the transformational dynamics of each construct.

Overall, the results of this study not only present a logical and data-driven argument but also provide a strong conceptual and practical foundation for efforts to develop a more competitive, green, and adaptive vocational education system. By integrating knowledge management and strategic project management and by strengthening green human capital, vocational institutions can improve their performance and actively support the inclusive and transformative sustainable development agenda, as mandated by the SDGs and the Industrial Revolution 5.0 framework.

This study contributes significantly to public sector management and organizational theory by pioneering the integration of the Knowledge-Based View (KBV) with Strategic Project Portfolio Management (SPPM) in a non-profit educational setting. Historically, KBV literature in higher education has focused heavily on the academic output of knowledge, often ignoring the governance structures required to deploy it. By introducing SPM as a parallel antecedent, this study theoretically demonstrates that intellectual assets require structured execution architectures to prevent organizational inertia. Furthermore, integrating the AMO framework to isolate Green Human Capital as a functional mediator enriches the human resource literature, proving that macro-level strategy cannot bypass micro-level human capability when predicting sustainable performance.

For Polytechnic Directors, Vice-Directors, and Academic Deans operating on the front lines, the research necessitates a profound paradigm shift in how strategic transformation is orchestrated internally. TEFAAs should not merely serve as pedagogical laboratories for honing green skills. However, they must be strategically governed as independent, revenue-generating business units. Applying Strategic Project Management enables TEFAAs to produce eco-friendly, market-ready products that provide sustainable funding streams for the institution, thereby reducing the institution's absolute reliance on state budgets. Leadership must explicitly integrate green product development and applied industrial sustainability research into the formal KPIs of academic staff. Innovation outputs that solve specific environmental bottlenecks for industry partners should carry greater weight in promotion cycles. Institutions must establish agile PMOs to act as the central nervous system, capturing explicit technical knowledge from business and industry (DUDI) partners and deploying it through well-governed internal projects (Fahadha et al., 2025).

For the National Coordination Team for the Revitalization of Vocational Education and Training (TKNV) and the Ministry of Higher Education, Sciences, and Technology (Kemendikbudristek), the findings call for recalibrating state funding mechanisms. National policymakers should meticulously design grant programs (such as the Matching Fund or Center of Excellence initiatives) that explicitly reward polytechnics for demonstrating measurable growth in their Green Human Capital. Linking institutional accreditation metrics and state funding approvals to the successful execution of strategic project portfolios will ensure greater accountability and significantly reduce the loss of vital educational funds (Fahadha et al., 2025).

Despite its robust methodological design, this study is not without limitations that warrant careful consideration. First, the data were collected exclusively from vocational institutions situated in Java, Indonesia. While these regions are highly representative of the nation's industrial hubs, the single-country context may limit the immediate generalizability of the findings to different cultural or international regulatory environments. Second, the

cross-sectional nature of the data captures a specific moment in time. The development of human capital and institutional transformation are inherently dynamic, multi-year processes.

CONCLUSIONS

This study confirms that sustainability transformation in vocational higher education cannot be achieved through fragmented efforts; it requires precise structural synchronization. By fully integrating the Ability-Motivation-Opportunity (AMO) framework within this sector, the findings establish that Green Human Capital (GHC) serves as a crucial, complementary partial mediator. It acts as a transformative bridge, translating macro-level project governance and organizational knowledge acquisition into sustainable strategic execution at the managerial level, ultimately driving improvements in institutional performance. Based on the empirical evidence that Knowledge Management (KM) and Strategic Project Management (SPM) are strong predictors of GHC, actionable implications emerge for institutional leaders. Vocational institutions are strongly encouraged to develop agile project management capabilities. To avoid bureaucratic friction, these capabilities should be seamlessly embedded within existing research and community service centers rather than operating as competing, corporate-style PMO silos. In alignment with the AMO framework, these strategic hubs must actively provide the structural opportunity for sustainable initiatives; robust KM systems must build the workforce's capacity through the continuous dissemination of eco-friendly competencies; and institutional appraisal systems must be realigned to provide the essential motivation for academic staff to adopt these practices.

Furthermore, because KM and SPM directly enhance institutional performance while fostering GHC, national policymakers, particularly the Ministry of Higher Education, Sciences, and Technology (Kemendiktisaintek), are advised to implement a regulatory framework that holistically supports both structural enablers and the development of green human capital. Recognizing the study's demographic scope within Java's advanced industrial agglomeration, these policies should not be imposed as rigid, nationwide mandates. Instead, the government is advised to initiate phased pilot programs. Policymakers can incrementally integrate localized GHC growth metrics and institutional project-readiness indicators as prioritized competitive advantages in national grant evaluations (e.g., the Matching Fund and Center of Excellence initiatives), starting with institutions in established industrial zones. By shifting toward phased, performance-based green incentivization, the government can organically institutionalize long-term sustainability. Because national policies must ultimately accommodate diverse infrastructural realities across regions, future research is strongly encouraged to adopt a longitudinal approach to track the dynamic evolution of GHC and to expand empirical observations across various geographic zones in developing countries to assess the generalizability of this model comprehensively.

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