

Teacher leadership for education for sustainable development in Indonesian vocational schools: Evidence from students' perspectives

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ARTICLE INFO

Article History

Received:

December 3, 2025;

Revised:

March 17, 2026;

Accepted:

July 3, 2026;

Keywords

Education for

Sustainable

Development (ESD);

PLS-SEM;

Sustainability;

Teacher leadership;

Vocational high school

ABSTRACT

This study investigates how teacher leadership supports Education for Sustainable Development (ESD) in Indonesian vocational high schools from students' perspectives. Specifically, it examines the effects of instructional, servant, and transformational leadership on students' perceptions of sustainability-oriented learning practices. Unlike previous studies, which have primarily focused on principal leadership or individual leadership approaches, this study integrates instructional, transformational, and servant leadership into a unified model to explain ESD implementation from students' perspectives. Using a quantitative cross-sectional design, data were collected through an online questionnaire completed by 779 vocational high school students in Central Java and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The results indicate that instructional leadership ($\beta = 0.404$), transformational leadership ($\beta = 0.243$), and servant leadership ($\beta = 0.157$) each have significant positive effects on sustainability-oriented education, collectively explaining 52.9% of the variance. Instructional leadership emerged as the strongest predictor, suggesting that lesson design, the facilitation of critical thinking, constructive feedback, and effective classroom practices are central to embedding ESD values in vocational education. The findings imply that professional development programs for vocational teachers should integrate pedagogical, inspirational, and ethical leadership competencies to strengthen ESD implementation. The study is limited by its cross-sectional design, reliance on student self-reports, convenience sampling, and regional focus. Therefore, future research should employ longitudinal, qualitative, and multi-stakeholder approaches to provide stronger evidence regarding causal relationships and contextual factors influencing ESD implementation.

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INTRODUCTION

The Sustainable Development Goals (SDGs) recognize that social, economic, and environmental development are closely interconnected and that progress in one dimension can influence outcomes in others. Education is central to this agenda because it can equip individuals not only with knowledge but also with the awareness, skills, values, and capacity to act in response to sustainability challenges. Through Education for Sustainable Development (ESD), United Nations Educational, Scientific and Cultural Organization (UNESCO) has therefore positioned education as an important means of enabling learners to make informed decisions and take responsible action toward a more sustainable future (Carney, 2021; Rieckmann, 2017). Within this educational agenda, teachers have an important role because their classroom practices and interactions with students can shape how sustainability principles are understood, internalized, and translated into everyday behavior.

Education provides an important foundation for developing the knowledge, attitudes, and competencies needed to address increasingly complex social and environmental challenges. Beyond

the acquisition of subject knowledge, students need opportunities to develop critical and creative thinking, social responsibility, and the ability to respond constructively to sustainability-related problems (Shobah et al., 2025). These expectations have encouraged secondary education systems to incorporate ESD principles into curricula and learning activities that connect global sustainability issues with students' local, social, economic, and environmental contexts (Rieckmann, 2017; Shobah et al., 2025). Evidence from previous research suggests that ESD-oriented learning can contribute to students' knowledge and awareness of sustainability and encourage greater participation in environmental protection and related activities (Laurie et al., 2016; Shobah et al., 2025).

Despite this growing attention, ESD remains less extensively studied in vocational secondary education than in other educational settings (Ferrer-Estévez & Chalmeta, 2021; Lambini et al., 2021). A systematic review by Edwards et al. (2020), for example, showed that ESD research has been concentrated geographically and has been more prominent in higher education than at the secondary level. This imbalance is particularly relevant to vocational education because vocational schools prepare students for occupations in which decisions about materials, energy, production, consumption, and workplace practices can have direct social and environmental consequences. In Indonesia, vocational high schools are expected not only to prepare students with occupational competencies but also to develop adaptability, character, social responsibility, and awareness of sustainability (Ferrer-Estévez & Chalmeta, 2021; Suharno et al., 2025). The integration of sustainability into vocational learning is therefore particularly important for students preparing to enter sectors such as manufacturing, automotive services, construction, and other resource-intensive industries.

Within this context, teachers are central to translating ESD principles from curriculum intentions into students' learning experiences. Their role extends beyond delivering subject content to creating learning environments in which students can critically examine sustainability issues, develop responsible behaviors, and connect occupational competence with broader social and environmental responsibilities (Asikainen & Tapani, 2021; Stössel et al., 2021). This role is consistent with the broader objectives of SDG 4 on quality education and SDG 8 on decent work and economic growth, which together highlight the importance of education that prepares individuals for productive participation in society while supporting sustainable development (Carney, 2021). For vocational education, this means preparing graduates who are technically competent while also being capable of making responsible decisions in their future workplaces (Suharno et al., 2025).

Teacher leadership offers a useful perspective for understanding how these objectives can be enacted in classroom practice. Rather than viewing teachers solely as implementers of prescribed curricula, teacher leadership recognizes their capacity to influence students through pedagogical decisions, interpersonal relationships, professional example, and the learning environment they create. Previous research has linked educational leadership with student self-efficacy and learning performance (Elfira et al., 2024). In the context of ESD, three leadership perspectives are particularly relevant: instructional, transformational, and servant leadership. Instructional leadership emphasizes the teacher's role in organizing effective learning, facilitating students' thinking, providing feedback, and supporting learning outcomes (Elfira et al., 2024). Transformational leadership emphasizes inspiration, motivation, vision, and exemplary behavior that can encourage students to embrace change and develop new ways of thinking (Meidelina et al., 2023). Servant leadership, in turn, foregrounds empathy, fairness, ethical responsibility, and concern for learners' needs and development (Weihua, 2025). Together, these perspectives capture complementary pedagogical, inspirational, and relational dimensions of teacher leadership that may be relevant to sustainability-oriented learning (Darwis et al., 2025).

Although these leadership perspectives have individually received considerable attention, their combined role in ESD within vocational secondary education remains insufficiently understood. Existing studies have often examined leadership dimensions separately or focused on leadership in educational settings without explicitly considering how different forms of teacher leadership may operate together to support sustainability-oriented learning (Darwis et al., 2025; Elfira et al., 2024). Research on ESD in vocational education also remains relatively limited, particularly in developing-country contexts such as Indonesia (Erin et al., 2022). Consequently, there is limited empirical evidence on whether instructional, transformational, and servant leadership make distinct

contributions when examined simultaneously within a single model of sustainability-oriented education in vocational schools.

A further gap concerns whose perspective is used to evaluate teacher leadership. Much of the leadership literature has traditionally focused on principals, teachers, or organizational outcomes, whereas students' perceptions have received comparatively less attention. Yet students directly experience teachers' instructional practices, motivational behaviors, interpersonal relationships, and everyday examples in the classroom. Their perspective can therefore provide valuable evidence about how teacher leadership is experienced in actual learning environments and how it relates to sustainability-oriented educational practices (Thoriq & Mahmudah, 2023). This perspective is particularly relevant in vocational schools, where sustainability principles need to be connected with both classroom learning and the practical competencies students will later apply in occupational settings.

Against this background, the present study integrates instructional, transformational, and servant leadership within a single conceptual model and examines their relationships with students' perceptions of sustainability-oriented education in Indonesian vocational high schools. The novelty of the study lies not simply in examining teacher leadership in relation to ESD, but in bringing together three theoretically distinct yet complementary leadership dimensions and evaluating them simultaneously from the perspective of vocational students. In doing so, the study responds to the need for a more integrated understanding of teacher leadership in ESD and extends the predominantly higher-education and non-vocational focus of previous sustainability research. It also provides empirical evidence from Indonesia, thereby contributing to the still developing literature on ESD and teacher leadership in vocational education within developing-country contexts.

Drawing on instructional leadership theory (York-Barr & Duke, 2004), transformational leadership theory (M. R. Beauchamp et al., 2014), and servant leadership theory (Eva et al., 2019), the proposed framework assumes that each leadership dimension represents a different pathway through which teachers may support sustainability-oriented education. Instructional leadership reflects the pedagogical pathway through which teachers structure learning, promote critical thinking, and facilitate students' development. Transformational leadership represents an inspirational pathway through which teachers motivate students, model desired behaviors, and encourage independent thinking. Servant leadership represents an ethical and relational pathway grounded in empathy, fairness, care, and concern for students and the wider community. Examining these dimensions simultaneously makes it possible to determine their respective relationships with sustainability-oriented education while accounting for their complementary roles within the same conceptual model.

Accordingly, this study aims to examine the relationships between instructional, servant, and transformational teacher leadership and students' perceptions of sustainability-oriented education in Indonesian vocational high schools. By testing these relationships within an integrated model, the study seeks to contribute theoretically to the teacher leadership and ESD literature and empirically to understanding how sustainability-oriented education is experienced by vocational students. The findings are also expected to inform the development of teacher professional learning and vocational education practices that connect pedagogical competence, inspirational leadership, and ethical care with the broader goals of sustainable development. Based on the conceptual framework presented in Figure 1, the following hypotheses are proposed:

H1: Instructional leadership is positively associated with students' perceptions of sustainability-oriented education.

H2: Servant leadership is positively associated with students' perceptions of sustainability-oriented education.

H3: Transformational leadership is positively associated with students' perceptions of sustainability-oriented education.

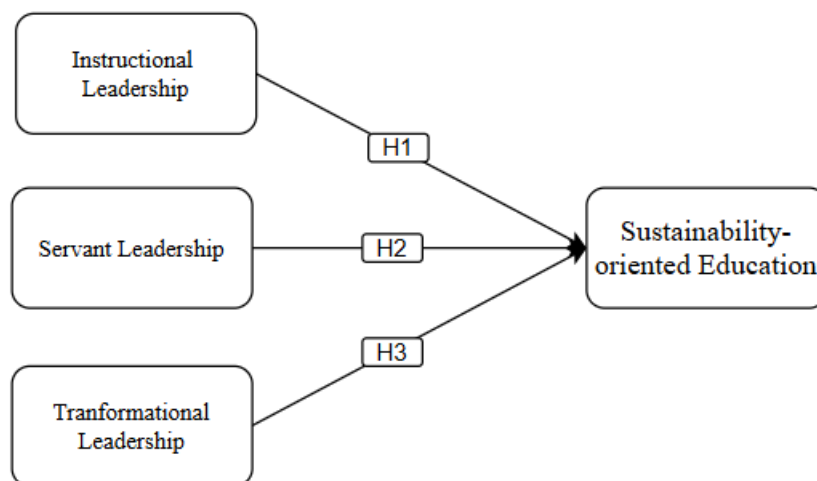


Figure 1. Conceptual Framework of the Study

METHOD

This study employed a quantitative cross-sectional design to examine the relationships between instructional, servant, and transformational teacher leadership and students' perceptions of sustainability-oriented education in Indonesian vocational high schools. The target population comprised vocational high school students in Central Java Province. Participants were recruited using convenience sampling, a non-probability sampling approach based on participant accessibility and willingness to participate (Stratton, 2021). To broaden the representation of experiences within the accessible population, students from different vocational programs and grade levels were included. Nevertheless, because probability sampling was not employed, the findings should be interpreted within the characteristics of the participating schools and students rather than generalized to the wider population of Indonesian vocational students.

The study involved 779 students from four vocational high schools located across three regencies/cities in Central Java Province. The participants were students in Grades 10–12 who had studied with the same teacher for at least one semester, ensuring sufficient experience with the teacher whose leadership practices they were asked to evaluate. The sample comprised 67 male students (8.6%) and 712 female students (91.4%), with an estimated response rate of 96%. The gender distribution reflected the characteristics of the vocational programs represented in the participating schools, particularly programs such as Office Management and Fashion Design, in which female students predominated. This imbalance was taken into account when interpreting the findings and is acknowledged as a limitation of the study.

Data were collected using an online questionnaire distributed through designated teachers at the participating schools. Permission to conduct the study was obtained from the headteachers before questionnaire distribution. The designated teachers facilitated access to the questionnaire, while students completed it independently. Before participation, students were informed about the purpose of the study and the voluntary nature of their involvement. Questionnaire responses were stored in a database accessible only to the researcher to maintain the confidentiality of the collected data.

The measurement instrument was adapted from established measures used in previous studies. Students' sustainability-oriented education was initially measured using ten items adapted from Boeve-de Pauw and Van Petegem (2018) and Olsson et al. (2022). Transformational leadership was measured using five items adapted from Beauchamp et al. (2014), servant leadership using five items adapted from Eva et al. (2019), and instructional leadership using seven items adapted from York-Barr and Duke (2004). All items were rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Because the original measures were adapted for Indonesian vocational school students, all items were translated into Indonesian using a forward–backward translation procedure to maintain

semantic equivalence with the source instruments. Two vocational education experts subsequently reviewed the translated questionnaire for readability, clarity, and contextual appropriateness. Particular attention was given to whether the wording was understandable to vocational students and whether the items remained consistent with the intended constructs within the SMK context.

The initial questionnaire contained 27 items and was pilot-tested with 50 respondents before the main data collection. Item validity and internal consistency were examined using SPSS version 25. Item validity was assessed through item correlations and their associated significance values. Most items met the specified criteria, whereas one item measuring students' sustainability-oriented education did not and was therefore removed before the main study. Internal consistency was assessed using Cronbach's alpha, with values above 0.70 considered acceptable. Following the pilot test, the final questionnaire consisted of 26 items: nine measuring students' sustainability-oriented education, seven measuring instructional leadership, five measuring servant leadership, and five measuring transformational leadership, as presented in Table 1.

Table 1. Constructs and Measurement Items

Construct	Item	Statement
Students' sustainability-oriented education	Y1	The teacher sets an example by disposing of trash properly.
	Y2	The teacher connects the lesson with environmental issues.
	Y3	The teacher motivates us to plant and care for plants at school.
	Y4	The teacher instills the importance of social justice and tolerance.
	Y5	The teacher encourages cooperation among students from different backgrounds.
	Y6	The teacher encourages students to actively discuss solutions to environmental problems.
	Y7	The teacher introduces the importance of managing finances wisely for the future.
	Y8	The teacher appreciates sustainable entrepreneurial ideas.
	Y9	The teacher acts as a role model for sustainable behavior at school.
Instructional Leadership	LL1	The teacher demonstrates a good spirit and method of learning.
	LL2	The teacher encourages me to think critically and creatively.
	LL3	The teacher explains the material in an easy-to-understand way.
	LL4	The teacher provides opportunities for discussion and collaboration in class.
	LL5	The teacher uses learning outcomes to help me develop.
	LL6	The teacher helps me become confident and independent in learning.
	LL7	The teacher involves students in determining the learning methods in class.
Servant Leadership	SL1	The teacher shows concern for my personal well-being.
	SL2	The teacher encourages me to develop my full potential.
	SL3	The teacher treats everyone fairly.
	SL4	The teacher cares about the well-being of the community outside of school.
	SL5	The teacher prioritizes my needs over their own.
Transformational Leadership	TL1	The teacher gives encouragement to make me more confident.
	TL2	The teacher inspires me to think independently.
	TL3	The teacher supports me in finding solutions to my own problems.
	TL4	The teacher cares about my needs and feelings as a student.
	TL5	The teacher sets a good example in attitude and behavior at school.

Partial Least Squares Structural Equation Modeling (PLS-SEM) was used to evaluate the proposed conceptual model. This approach was selected because of its suitability for prediction-oriented structural models, its flexibility in handling complex relationships among latent constructs, and its ability to accommodate data that may not meet multivariate normality assumptions (Hair et al., 2019). Compared with covariance-based structural equation modeling (CB-SEM), which places greater emphasis on reproducing the empirical covariance matrix and overall model fit, PLS-SEM is particularly appropriate for prediction-oriented analyses and models for which less restrictive distributional assumptions are desirable (Dash & Paul, 2021). The analysis was conducted using SmartPLS version 4.1.4.

Following the recommendations of Hair et al. (2019), the PLS-SEM analysis proceeded through evaluation of the measurement and structural models. All constructs were specified as reflective because the observed indicators were conceptualized as manifestations of their respective

latent constructs. The measurement model was evaluated in terms of indicator reliability, internal consistency reliability, convergent validity, and discriminant validity. Indicator loadings were examined together with Cronbach's alpha and composite reliability (CR), while average variance extracted (AVE) was used to assess convergent validity. Discriminant validity was examined using the heterotrait–monotrait ratio (HTMT).

After establishing the adequacy of the measurement model, the structural model was evaluated to examine the proposed relationships among the latent constructs. Collinearity among predictor constructs was assessed using the variance inflation factor (VIF), with values below 3.0 used as a conservative criterion. The model's explanatory and predictive performance was assessed using the coefficient of determination (R^2), effect size (f^2), and predictive relevance (Q^2). Finally, the proposed hypotheses were tested using a bootstrapping procedure with 5,000 subsamples, two-tailed significance testing, and 95% bias-corrected and accelerated (BCa) confidence intervals. Structural relationships were interpreted on the basis of the magnitude and direction of the path coefficients, confidence intervals, and statistical significance. Given the cross-sectional and non-probability design of the study, these structural relationships were interpreted as predictive associations rather than evidence of causal effects.

RESULTS AND DISCUSSION

Results

Outer Model

At this stage, the researchers tested the reliability of research instruments to assess the extent to which the indicators used can adequately represent latent constructs that are valid and reliable. Validity was assessed by looking at the factor loading value, where each indicator is considered valid if it has a value greater than 0.50 (Byon & Jang, 2024). Although a stricter threshold of 0.70 is often recommended for confirmatory research, a threshold of 0.50 was adopted given the exploratory nature of integrating three leadership constructs within a single model, consistent with Hair et al. (2019). Indicators Y8 (0.594) and SL5 (0.535) were retained despite their comparatively lower loadings, as their removal did not improve the AVE of the respective constructs and their content (appreciation for sustainable entrepreneurial ideas; prioritizing students' needs) was judged conceptually essential to construct coverage. In addition, construct validity can also be strengthened through an Average Variance Extracted (AVE) value that must be greater than 0.50, indicating that the latent variable can explain more than half of the variance of the indicators (Byon & Jang, 2024).

Meanwhile, reliability was assessed using two main measures, namely Cronbach's Alpha and Composite Reliability (CR). A construct is considered reliable if it has a Cronbach's Alpha value above 0.70, which indicates the internal consistency of the indicators in measuring the latent variable. Similarly, a Composite Reliability value greater than 0.70 provides additional evidence that the construct has good reliability (Hair et al., 2019).

Furthermore, construct reliability testing was conducted using two main measures, namely Composite Reliability (CR) and Average Variance Extracted (AVE). The analysis results showed that the CR values of each variable were above the threshold of 0.70, namely: sustainable education (0.879), transformational leadership (0.860), instructional leadership (0.891), and servant leadership (0.820). This indicates that all constructs in the study have good internal consistency and are reliable.

In addition, the AVE values obtained for each construct also exceeded the threshold of 0.50, indicating that the latent variables explained more than half of the variance of the indicators. Thus, these findings indicate that the measurement model demonstrated acceptable validity and reliability and reliable, so it can proceed to the structural model analysis stage (inner model). Next, the HTMT value was tested to assess discriminant validity. The statistical output shows that the HTMT value obtained is less than 0.900, which means that the constructs and variables used in the study are statistically different from one another (Table 3).

Table 2. Outer Model Testing

Variable	Construct	Outer loading	Cronbach Alpha	Composite Reliability	AVE
Students' sustainability-oriented education	Y1	0.687	0.874	0.879	0.500
	Y2	0.711			
	Y3	0.755			
	Y4	0.633			
	Y5	0.748			
	Y6	0.765			
	Y7	0.713			
	Y8	0.594			
	Y9	0.741			
Instructional Leadership	LL1	0.801	0.886	0.891	0.595
	LL2	0.777			
	LL3	0.717			
	LL4	0.773			
	LL5	0.825			
	LL6	0.821			
	LL7	0.677			
Servant Leadership	SL1	0.821	0.792	0.820	0.544
	SL2	0.819			
	SL3	0.703			
	SL4	0.770			
	SL5	0.535			
Transformational Leadership	TL1	0.820	0.854	0.860	0.631
	TL2	0.819			
	TL3	0.752			
	TL4	0.788			
	TL5	0.791			

Table 3. HTMT (Heterotrait–Monotrait Ratio)

	LL	SL	TL	Y
LL				
SL	0.777			
TL	0.832	0.809		
Y	0.777	0.681	0.739	

Inner model

The structural model was subsequently evaluated, which aims to examine the relationship between variables in the study. The test was conducted using R^2 and SRMR values as shown in Table 4. An R^2 value is considered adequate if it is greater than 0.1. The analysis results show that 52.9% of the variance in students' sustainability-oriented education can be explained by instructional leadership, servant leadership, and transformational leadership. Not only the R^2 value, but also the Q^2 was examined to assess the model's predictive relevance the relationship between variables was significantly predictive or not. This study reports that the Q^2 value obtained was 0.522, confirming that the predictive relevance of the study was achieved. In addition, the SRMR value obtained was 0.067. These findings confirm that the model proposed in the study is appropriate and suitable for use in answering the research topic.

Table 4. R^2 and SRMR Values

Variable	R^2	Adj. R^2	SRMR	Q^2
(Y)	0.529	0.528	0.067	0.522

The Variance Inflation Factor (VIF) is used to test for multicollinearity amongst the independent variables that collectively predict the dependent variable. This test aims to ensure that no individual independent variable is too highly correlated with the others, so that each can make a distinct contribution to explaining the dependent variable. The results of the analysis show that all

VIF values are below 3 (Table 5), indicating the absence of multicollinearity. Consequently, the three leadership constructs, namely instructional leadership, servant leadership, and transformational leadership, make distinct contributions and do not overlap excessively in explaining students' sustainability-oriented education.

Table 5. Variance Inflation Factor (VIF)

	VIF
LL -> Y	2.434
SL -> Y	2.207
TL -> Y	2.543

Furthermore, the effect size (f^2) was used to measure the extent to which each independent variable contributed to the dependent variable. Based on the results of the analysis (Table 6), instructional leadership had an f^2 value of 0.143, indicating a small effect and representing the largest contribution compared with the other variables. Meanwhile, transformational leadership had an f^2 value of 0.049 and servant leadership of 0.024, both of which also fall into the small effect category. These findings suggest that although all three variables contribute to students' sustainability-oriented education, instructional leadership has a relatively stronger influence than transformational leadership and servant leadership.

Table 6. Effect size (F^2)

	Y
LL	0.143
SL	0.024
TL	0.049

Hypothesis Testing

The final stage of this study was to test the proposed hypotheses. Testing in PLS-SEM used the bootstrapping procedure with a significance level of 5%. Statistical analysis using SmartPLS 4 software in Table 7 and Figure 2 showed that all hypothesized relationships were statistically significant on sustainable education. The test results show that instructional leadership has a positive and significant effect on students' sustainability-oriented education with a p-value of 0.000 and a T-statistic of 8.831. Furthermore, servant leadership is also proven to have a positive and significant effect with a p-value of 0.000 and a T-statistic of 3.790. Similarly, transformational leadership has a positive and significant effect on sustainable education with a p-value of 0.000 and a T-statistic of 5.421. Thus, it can be confirmed that all three forms of leadership, namely instructional, servant, and transformational, were significantly associated with sustainable education.

The 95% confidence intervals indicate that all structural relationships are statistically significant because none of the intervals include zero (Table 7). Specifically, instructional leadership showed a positive effect on students' perceived sustainability-oriented learning practices ($\beta = 0.404$; 95% CI = 0.317–0.495), followed by transformational leadership ($\beta = 0.243$; 95% CI = 0.155–0.334) and servant leadership ($\beta = 0.157$; 95% CI = 0.076–0.240). These findings suggest that the positive effects of the three leadership styles are robust and consistent across bootstrap samples.

Beyond statistical significance, the effect size analysis provides evidence of practical significance. Instructional leadership demonstrated the largest effect size ($f^2 = 0.143$), indicating that teachers' instructional practices contribute more substantially to students' perceived sustainability-oriented learning practices than transformational leadership ($f^2 = 0.049$) and servant leadership ($f^2 = 0.024$). Although all three effect sizes are classified as small according to Cohen's guidelines, the findings highlight that leadership behaviors directly related to classroom instruction play a more meaningful role in fostering sustainability-oriented learning than leadership behaviors primarily centered on inspiration or service.

Table 7. Hypothesis Testing

Hypothesis	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	P values	CI Lower 2.5%	CI Upper 97.5%
LL -> Y	0.404	0.405	0.046	8.831	0.000	0.317	0.495
SL -> Y	0.157	0.157	0.041	3.790	0.000	0.076	0.240
TL -> Y	0.243	0.243	0.045	5.421	0.000	0.155	0.334

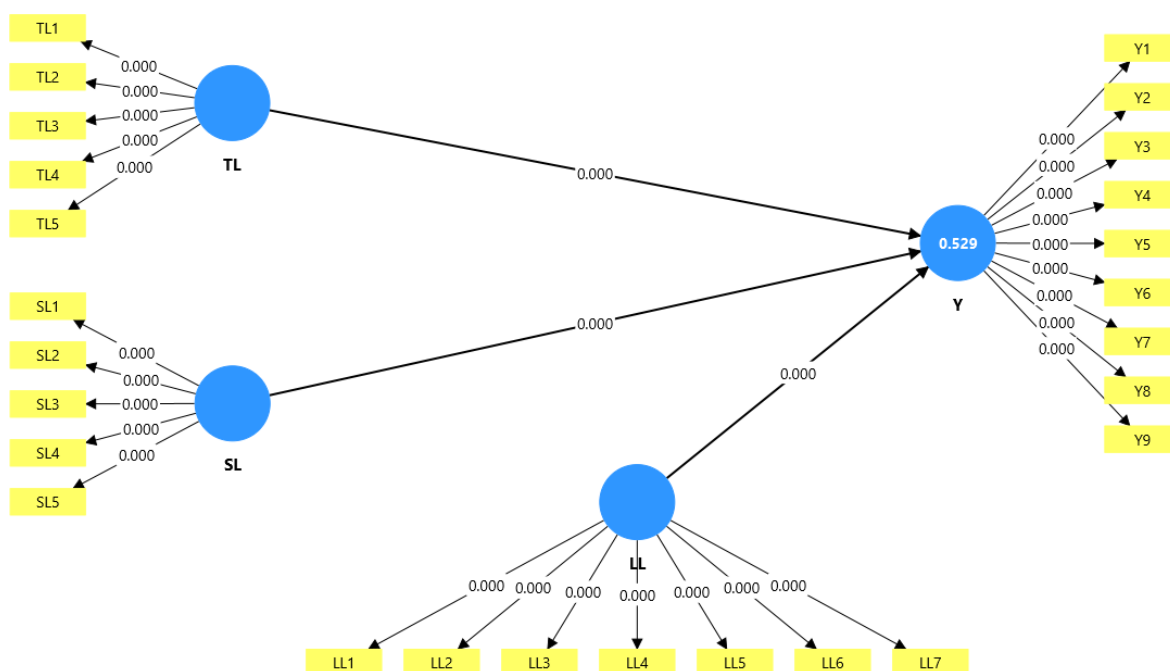


Figure 2. Research Model Proposed After Analysis

Discussion

This study examined how instructional, servant, and transformational teacher leadership are associated with students' perceptions of sustainability-oriented education in Indonesian vocational high schools. The findings support all three proposed hypotheses, indicating that each leadership dimension contributes positively to sustainability-oriented learning, although their relative contributions differ. Instructional leadership showed the strongest association ($\beta = 0.404$, $p < 0.001$), followed by transformational leadership ($\beta = 0.243$, $p < 0.001$) and servant leadership ($\beta = 0.157$, $p < 0.001$). Together, the three constructs explained 52.9% of the variance in students' sustainability-oriented education. These findings extend previous discussions of leadership and sustainability in education (Arbuzova & Alexandrova, 2024; Eva et al. 2019; Uline & Kensler, 2021) by showing that, from students' perspectives, sustainability-oriented learning in vocational schools is associated with a combination of pedagogical, inspirational, and relational dimensions of teacher leadership rather than with a single leadership approach.

Instructional Leadership and the Pedagogical Integration of ESD

The finding for instructional leadership supports H1 and suggests that classroom practices are particularly important in translating ESD principles into students' learning experiences. Its standardized path coefficient ($\beta = 0.404$) was the largest among the three leadership dimensions, while its effect size ($f^2 = 0.143$) was also larger than those of transformational and servant leadership. Although the effect size remains within the small range, the relative pattern indicates that leadership behaviors closely connected to teaching and learning are more strongly associated with students'

perceptions of sustainability-oriented education than the other leadership dimensions examined in this study.

This finding can be understood through the theoretical perspective of teacher leadership proposed by York-Barr and Duke (2004), in which teachers exercise leadership through their influence on teaching, learning, and school improvement. In the context of ESD, such influence becomes particularly relevant when teachers connect subject content with environmental and social issues, encourage critical and creative thinking, facilitate collaborative learning, and use information about learning outcomes to support students' development. Rather than treating sustainability as an additional topic outside the core curriculum, these practices allow ESD principles to become part of everyday classroom learning. This interpretation is consistent with Leithwood et al. (2020), who emphasized the importance of leadership practices for improving learning conditions, and with studies highlighting the value of integrating sustainability into curriculum and instructional practice (Fattizzi & Grigione, 2023; Yadav, 2024).

The comparatively stronger contribution of instructional leadership may also reflect the practice-oriented character of vocational education. Vocational high schools are designed around the integration of knowledge, skills, and applied learning. In such settings, teachers have opportunities to connect sustainability with concrete occupational practices, including resource use, problem-solving, production processes, and workplace decision-making. Sustainability can therefore be experienced through what students actually do during learning rather than being addressed only as an abstract principle. This may explain why students respond particularly strongly to leadership practices that directly shape instruction. The finding suggests that ESD in vocational education is likely to be more meaningful when sustainability principles are embedded in subject teaching, practical activities, and vocational problem-solving rather than presented as an isolated curricular theme.

Transformational Leadership and Sustainability-Oriented Agency

Transformational leadership was also positively associated with sustainability-oriented education, supporting H3 ($\beta = 0.243$, $p < 0.001$). Although its effect size was small ($f^2 = 0.049$), the finding indicates that students' sustainability-oriented learning is related not only to how teachers organize instruction but also to how they inspire, encourage, and model desirable attitudes and behaviors. From this perspective, transformational leadership complements instructional leadership by addressing the motivational and aspirational dimensions of ESD.

This interpretation is consistent with transformational leadership theory, which emphasizes the capacity of leaders to articulate meaningful goals, provide positive role models, and encourage individuals to reconsider established ways of thinking. Within the classroom, teachers who encourage students to think independently and demonstrate responsible behavior can help students develop a sense of agency in responding to sustainability challenges. This is particularly relevant to ESD because sustainability requires more than knowledge acquisition; students must also be willing to reflect on their choices and recognize their capacity to contribute to social and environmental change.

The finding is broadly consistent with Alabdali et al. (2024) and Widisatria and Nawangsari (2021), who linked transformational leadership with environmentally oriented attitudes and behaviors in organizational contexts. The present study extends this line of inquiry to vocational education by showing that transformational leadership is also positively associated with students' perceptions of sustainability-oriented learning. However, its smaller contribution relative to instructional leadership suggests that inspiration and role modelling may be most meaningful when accompanied by concrete pedagogical opportunities through which students can apply sustainability principles. Transformational leadership may therefore provide motivational direction, whereas instructional leadership provides the classroom mechanisms through which that direction is translated into learning experiences.

Servant Leadership as a Relational Foundation for ESD

The findings also support H2, showing a positive relationship between servant leadership and students' sustainability-oriented education ($\beta = 0.157$, $p < 0.001$). Servant leadership had the

smallest effect size among the three dimensions ($f^2 = 0.024$), suggesting a comparatively modest contribution within the structural model. This finding should not, however, be interpreted as indicating that relational and ethical aspects of teacher leadership are unimportant. Rather, servant leadership may operate through a less direct pathway by creating interpersonal conditions that support students' engagement with sustainability-oriented learning.

Servant leadership emphasizes care, fairness, personal development, and concern for the wider community. These characteristics are conceptually relevant to ESD because sustainability includes social and ethical dimensions alongside environmental concerns. Teachers who demonstrate concern for students' well-being, treat students fairly, and show responsibility toward the wider community may provide students with everyday examples of the values underlying sustainable and socially responsible behavior. In this sense, servant leadership can provide a relational and ethical foundation within which sustainability-oriented learning takes place.

This interpretation is consistent with Ying et al. (2020), who found that servant leadership can foster environmentally responsible behavior, and Darvishmotevali and Altinay (2022), who identified servant leadership as an important condition in the relationship between environmental awareness and green behavior. While these studies were conducted outside the school context, the present findings suggest that similar relational mechanisms may also be relevant in vocational education. At the same time, the comparatively small effect observed here indicates that care and empathy alone may not be sufficient to translate sustainability principles into specific learning practices. Their contribution may become more meaningful when combined with instructional strategies and transformational behaviors that provide students with opportunities and motivation to act on those values.

Integrating Teacher Leadership for Sustainability-Oriented Vocational Education

Taken together, the findings provide empirical support for the conceptual framework proposed in this study, in which instructional, transformational, and servant leadership represent distinct but complementary dimensions of teacher leadership. Instructional leadership provides the pedagogical mechanisms through which sustainability can be incorporated into learning; transformational leadership contributes motivational direction and encourages student agency; and servant leadership provides the relational and ethical conditions that support socially responsible learning. The significance of all three paths suggests that teacher leadership for ESD cannot be reduced to a single set of classroom behaviors.

This integrated perspective represents an important contribution to the teacher leadership and ESD literature. Previous research has often examined individual leadership approaches or leadership at the school-management level. By examining three teacher-level leadership dimensions simultaneously and using students as the primary respondents, this study shifts attention to how leadership is experienced within everyday classroom interactions. This perspective is particularly relevant in vocational education, where teachers occupy a dual position as educators and facilitators of occupational preparation. Their leadership may therefore influence not only students' learning experiences but also how future workers understand responsible professional practice.

The findings also have implications for teacher development and vocational education practice. Professional development for vocational teachers could place greater emphasis on integrating sustainability into instructional design, practical assignments, collaborative problem-solving, and feedback, while also developing teachers' capacity to motivate students and establish supportive classroom relationships. The comparatively stronger association of instructional leadership suggests that pedagogical integration deserves particular attention. Nevertheless, the findings do not imply that one leadership style should replace the others. Instead, teacher development may benefit from treating pedagogical, transformational, and relational competencies as complementary aspects of leadership for ESD. Such an approach would also be consistent with the broader purpose of vocational education: preparing students not only for employment but also for responsible participation in workplaces and communities facing increasingly complex sustainability challenges.

Limitations and Future Research

Several limitations should be considered when interpreting these findings. First, the cross-sectional design identifies associations among teacher leadership and sustainability-oriented education but does not establish causal relationships. Second, all constructs were assessed through students' self-reports, which capture students' perceptions of teacher leadership and sustainability-oriented learning rather than directly observed teaching practices or behavioral sustainability outcomes. The use of a single data source may also increase the possibility of common method and perceptual bias. Third, convenience sampling was used, and participants were drawn from four vocational schools in Central Java. The findings should therefore be interpreted within this regional and institutional context rather than generalized to all Indonesian vocational schools. In addition, the sample was predominantly female (91.4%), reflecting the characteristics of the vocational programs represented in the participating schools, which may further limit the transferability of the findings across different vocational fields and student populations.

Future research could address these limitations through longitudinal or multi-wave designs that examine how teacher leadership and students' sustainability orientations develop over time. Studies involving teachers, school leaders, and other stakeholders alongside students would provide a more comprehensive assessment of leadership for ESD, while classroom observations could help distinguish perceived leadership from enacted instructional practices. More diverse samples across provinces, vocational specializations, and school characteristics would also strengthen the external validity of the findings. Given the pronounced gender imbalance in the present sample, future studies could use more balanced samples and examine whether the structural relationships differ across gender or vocational fields through multi-group analysis. Qualitative or mixed-methods research may further clarify how instructional, transformational, and servant leadership interact in specific classroom and workplace-learning contexts. These approaches would help determine not only whether particular leadership practices are associated with sustainability-oriented education, but also how and under what conditions they contribute to students' sustainability competencies.

CONCLUSION

This study provides empirical evidence that instructional, transformational, and servant teacher leadership are positively associated with students' perceptions of sustainability-oriented education in Indonesian vocational high schools. Among the three dimensions, instructional leadership showed the strongest association ($\beta = 0.404$), followed by transformational leadership ($\beta = 0.243$) and servant leadership ($\beta = 0.157$), with the three constructs collectively explaining 52.9% of the variance in sustainability-oriented education. Although the individual effect sizes were relatively small, the findings suggest that sustainability-oriented learning is associated with complementary dimensions of teacher leadership: pedagogical practices that integrate sustainability into learning, inspirational behaviors that encourage students' agency, and relational practices grounded in care and social responsibility. By examining these three leadership dimensions simultaneously from students' perspectives, this study contributes to the teacher leadership and ESD literature and provides evidence from vocational education in a developing-country context. The findings also suggest that efforts to strengthen ESD in vocational schools may benefit from professional development that integrates instructional, transformational, and relational leadership competencies rather than treating them as separate approaches.

These findings should be interpreted within the scope of the study. The cross-sectional design does not establish causal relationships, while reliance on student self-reports may introduce perceptual and common-method bias. In addition, convenience sampling, the inclusion of students from only four vocational schools in Central Java, and the predominantly female sample limit the extent to which the findings can be generalized to other vocational education settings. Future research should therefore examine these relationships using longitudinal or multi-wave designs, more diverse and representative samples across vocational fields and regions, and multiple sources of evidence, including teachers, school leaders, classroom observations, and behavioral measures of sustainability-related learning. Qualitative and mixed-methods studies could further clarify how instructional, transformational, and servant leadership interact in specific classroom and workplace-learning contexts, while multi-group analyses could examine whether these relationships vary across

gender, vocational specialization, or school characteristics. Such research would provide a stronger basis for understanding how teacher leadership can support the integration of ESD into vocational education.

ACKNOWLEDGMENTS

This work was supported by the Research and Community Service Institute (LPPM) of Universitas Sebelas Maret under Grant 897/UN27/HK.02/2025.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : Conceptualization
M : Methodology
So : Software
Va : Validation
Fo : Formal analysis
I : Investigation
R : Resources
D : Data Curation
O : Writing - Original Draft
E : Writing - Review & Editing
Vi : Visualization
Su : Supervision
P : Project administration
Fu : Funding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial or non-financial interests that could have appeared to influence the work reported in this paper.

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