Indonesian Journal of Educational Development (IJED)
Volume 7, Issue 2, 2026, pp. 784-799
ISSN: 2722-1059 (Online); ISSN: 2722-3671 (Print)
DOI: https://doi.org/10.59672/ijed.v7i2.6694

Differentiated instruction strategy model to improve vocational students' outcomes based on learning needs

Margaretha Karolina Sagala[1], Agus Suyatna*)[2], Viyanti[3], Rangga Firdaus[4]
[1]Universitas Lampung, Bandar Lampung, Indonesia; margaretha.karolina@fkip.unila.ac.id
[2]Universitas Lampung, Bandar Lampung, Indonesia; agus.suyatna@fkip.unila.ac.id
[3]Universitas Lampung, Bandar Lampung, Indonesia; viyanti.1980@fkip.unila.ac.id
[4]Universitas Lampung, Bandar Lampung, Indonesia; ranggafirdaus@fkip.unila.ac.id
*) Corresponding Author: Agus Suyatna; E-mail addresses: agus.suyatna@fkip.unila.ac.id

Article Info

Article history:
Received June 13, 2026
Revised July 04, 2026
Accepted July 17, 2026
Available online August 17, 2026

Keywords: Differentiated Learning, Learning Outcomes, SEM-PLS, Student Needs, Vocational High School

Copyright ©2026 by Author. Published by Lembaga Penelitian dan Pengabdian kepada Masyarakat (LPPM) Universitas PGRI Mahadewa Indonesia

Abstract. Learning in Vocational High Schools (VHS) requires instructional strategies that can accommodate the diversity of students' needs, characteristics, and learning readiness. However, predominantly uniform instructional practices are often not optimal for comprehensively improving students' learning outcomes. This study aims to develop a differentiated learning strategy model based on students' needs to enhance the learning outcomes of vocational high school students. The study employed a quantitative approach using an explanatory survey design. The research participants consisted of vocational high school students, and data were collected through instruments designed to identify students' needs, assess the implementation of differentiated learning strategies, and measure learning outcomes. The data were analyzed using Structural Equation Modeling–Partial Least Squares (SEM-PLS) to examine the relationships among the constructs in the proposed model. The findings indicate that differentiated learning strategies positively affect students' learning outcomes, while identifying students' needs also significantly influences both the implementation of learning strategies and learning achievement. These findings confirm that adaptive, personalized, and student-centered learning is more effective than uniform instructional approaches. This study's novelty lies in developing a differentiated learning model for the vocational education context, based on students' needs and validated using the SEM-PLS approach. This research strengthens the conceptual and practical foundations for developing adaptive learning in vocational education to improve both the quality of the learning process and learning outcomes.

Introduction

Vocational education plays a crucial role in preparing graduates who are competent, adaptive, and able to meet workforce demands (Kholifah et al., 2025; Ogunleeye, 2026; Muharam et al., 2025). In practice, vocational high school students show diverse learning characteristics in academic readiness, interests, and learning profiles (Goyibova et al., 2025; Yousef, 2024). This diversity requires teachers to move beyond uniform instructional approaches for all students (Nketsia et al., 2025; Sugiyanto et al., 2026). Learning strategies that are responsive to students' varying needs have become increasingly important for improving the quality of the learning process (Isnaini & Widyasari, 2025; Goyibova et al., 2025). In this context, differentiated learning is an approach that can bridge students' individual needs with established learning objectives (Maulana et al., 2025; Liou et al., 2023).

Differentiated learning is an instructional strategy that adapts content, learning processes, products, and learning environments to students' characteristics and needs (Goyibova et al., 2025; Langelaan et al., 2024). This approach emphasizes that learning is more effective when experiences are designed around learners' actual needs (Flores et al., 2024; Hua et al., 2024). In Vocational High Schools (VHSs), differentiated learning is particularly important because the focus extends beyond conceptual understanding to include the development of practical skills and workforce readiness (Goyibova et al., 2025; Ratnawulan et al., 2026). Students' learning outcomes are strongly influenced by how well instructional practices accommodate their diverse learning needs (Liou et al., 2023). Therefore, developing a differentiated learning strategy model is highly relevant to strengthening the quality of teaching and learning in vocational education (Langelaan et al., 2024).

Instructional practices in Vocational High Schools (VHSs) still frequently use uniform approaches that do not adequately consider the diversity of students' learning needs (Royyani & Gozali, 2025; Annisa et al., 2023). Instructional models currently used in practice are not yet fully grounded in systematic, structured assessments of students' needs. Furthermore, existing studies on differentiated learning in vocational education have paid limited attention to developing empirically validated models (Niu et al., 2026; Zuo et al., 2025). In addition, researchers have rarely examined the relationships among differentiated learning strategies, students' needs, and learning outcomes through comprehensive structural modeling approaches (Hattie & Leary, 2025; Langelaan et al., 2024). Consequently, robust models that explain how differentiated learning strategies can systematically enhance vocational high school students' learning outcomes remain lacking.

This study matters because vocational high school students have diverse learning needs that require adaptive, targeted instructional strategies. Improving learning outcomes cannot be achieved through uniform teaching approaches alone; it requires instructional models aligned with students' specific needs, interests, and learning readiness (Seprie et al., 2025; Fitas, 2025). Furthermore, the development of a model using the Structural Equation Modeling–Partial Least Squares (SEM-PLS) approach provides empirical evidence regarding the relationships among the variables involved in differentiated learning, thereby offering a more comprehensive understanding of the mechanisms through which learning outcomes can be improved (Bayaga, 2026; Dukalang et al., 2025).

This research is urgent because vocational education needs stronger learning quality through instructional strategies that respond to students' diverse needs in a more personalized, measurable, and effective way (Widana et al., 2023). As vocational education continues to face increasing demands to produce competent, work-ready graduates, implementing adaptive learning strategies has become essential to ensure optimal learning outcomes (Rusmiyati et al., 2026; Ogunleeye, 2026). This study proposes a novel differentiated learning strategy model based on the specific needs of vocational high school students and validates it using the SEM-PLS approach. The proposed model provides a more systematic conceptual and empirical framework for understanding the relationships among students' needs, differentiated learning strategies, and learning outcomes. Consequently, it contributes both theoretically and practically to evidence-based instructional decision-making in vocational education.

This study aims to develop a differentiated learning strategy model oriented toward the needs of vocational high school students and to examine the relationships among differentiated learning strategies, students' needs, and learning outcomes using the Structural Equation Modeling–Partial Least Squares (SEM-PLS) approach. Specifically, the study examines whether differentiated learning strategies designed around students' needs positively affect vocational high school students' learning outcomes.

In addition, this study aims to develop an instructional model that can serve as a foundation for adaptive learning practices in vocational education. By providing empirical evidence on the relationships among the key constructs, the proposed model is expected to support more effective, student-centered instructional decision-making in vocational schools. Based on the conceptual framework, the following hypotheses are proposed: (1) H1: Differentiated learning strategies have a positive effect on vocational high school students' learning outcomes; (2) H2: Students' needs positively affect the implementation of differentiated learning strategies; (3) H3: Students' needs have a positive effect on vocational high school students' learning outcomes; (4) H4: Differentiated learning strategies mediate the effect of students' needs on vocational high school students' learning outcomes.

Method

Research Method and Design

This study employed a quantitative approach using an explanatory survey design (Nicmanis, 2024). This design was selected to examine the structural relationships among the variables in the proposed model: students' needs, differentiated learning strategies, and learning outcomes. The study aimed not only to investigate the direct effects among these variables but also to develop an empirical model that explains the mechanisms through which differentiated learning strategies contribute to improved student learning outcomes.

Participants and Sampling Technique

The research participants were 100 vocational high school students enrolled in vocational programs relevant to the study context. Participants were selected based on their direct involvement in learning experiences that allowed the implementation of differentiated learning strategies. Participant characteristics may include grade level, vocational program, gender, and diverse learning experiences. This section still requires actual data from your study, such as the number of students, school location, vocational program, and key demographic characteristics.

Research Setting and Timeline

This research was conducted at SMK Negeri 1 Bandar Lampung, a vocational high school located in Bandar Lampung, Indonesia. The school was selected because it represented the vocational education context in which student learning needs and differentiated instruction practices could be examined. The study was conducted from February 2026 to April 2026. The research process included identifying students' learning needs, developing and validating the research instrument, collecting data, and analyzing the data. Provide a clear timeline showing the sequence and duration of each research stage.

Research Procedures

The study population consisted of all vocational high school students at the selected research sites. The sampling technique may employ proportionate stratified random sampling, cluster sampling, or purposive sampling, depending on the field design and the researcher's access to participants (Zrineh et al., 2026). In SEM-PLS-based research, the sample size must meet the requirements for structural model analysis as well as the number of indicators within each construct. This section still needs to be completed with information regarding the population size, the final sampling technique, the actual sample size, and the rationale for its selection.

Data Collection Techniques and Research Instruments

The research instrument was designed as a closed-ended questionnaire using a Likert scale to measure students' perceptions of learning needs, differentiated learning strategies, and learning outcomes (Liou et al., 2023). The students' needs construct may include indicators of learning readiness, learning interests, and learning profiles. The differentiated learning strategy construct may include content differentiation, process differentiation, product differentiation, and learning support differentiation. The learning outcomes construct may be measured through perceptions of learning achievement, subject-matter understanding, applied skills, and academic performance relevant to the vocational high school context. Experts should review the instrument's content validity, while construct validity and internal reliability will be tested through SEM-PLS using outer loading, Average Variance Extracted (AVE), composite reliability, and Cronbach's alpha.

Table 1. Research instrument blueprint

Variable	Dimension/Indicator	Item Numbers	Number of Items	Scale
Students' Learning Needs	Learning readiness	1–4	4	Likert 1–5
Students' Learning Needs	Learning interests	5–8	4	Likert 1–5
Students' Learning Needs	Learning profiles	9–12	4	Likert 1–5
Differentiated Instruction Strategies	Content differentiation	13–16	4	Likert 1–5
Differentiated Instruction Strategies	Process differentiation	17–20	4	Likert 1–5
Differentiated Instruction Strategies	Product differentiation	21–24	4	Likert 1–5
Differentiated Instruction Strategies	Learning support differentiation	25–28	4	Likert 1–5
Learning Outcomes	Academic achievement	29–32	4	Likert 1–5
Learning Outcomes	Understanding of subject matter	33–36	4	Likert 1–5
Learning Outcomes	Applied vocational skills	37–40	4	Likert 1–5
Learning Outcomes	Overall learning performance	41–44	4	Likert 1–5

The research instrument consisted of three main sections. The first section included respondent identification information to map students' basic characteristics. The second section measured students' needs through statements representing learning readiness, interests, and learning profiles. The third section measured differentiated learning strategies and learning outcomes through indicators relevant to the learning process in vocational high schools. Responses were scored using a Likert scale, for example, ranging from strongly disagree to strongly agree. This section would be strengthened by adding the number of items for each variable, sample items, sources used for item development, and the results of expert validation.

The study began by identifying students' needs through a preliminary study and developing indicators for each variable. The researcher then developed the research instrument, conducted content validation, and, if necessary, carried out a pilot test. After the instrument was deemed appropriate, the researcher collected data from respondents during the predetermined research period. The collected data were then cleaned, coded, and analyzed using SEM-PLS to evaluate the measurement and structural models. This section still requires specific information on the research timeline, implementation stages in the schools, and ethical procedures.

Instrument Validity and Reliability Tests

The instrument's validity and reliability were assessed in several stages. *First*, content validity was examined through expert judgment involving 3 experts in education, vocational learning, and instructional design. The experts reviewed each item's relevance, clarity, and appropriateness in representing the intended construct. *Second*, construct validity was tested using SEM-PLS by examining each indicator's outer loading and the Average Variance Extracted (AVE). Indicators with outer loading values greater than 0.70 were considered acceptable, although values above 0.60 could still be retained in exploratory studies if theoretically justified. AVE values above 0.50 indicated adequate convergent validity. *Third*, discriminant validity was examined using the Fornell-

Larcker criterion and/or cross-loadings to ensure that each construct was empirically distinct from the others. Reliability was evaluated using Cronbach's alpha and composite reliability. A construct was considered reliable if both Cronbach's alpha and composite reliability values exceeded 0.70

Data Analysis Techniques and Criteria

Data analysis used Structural Equation Modeling–Partial Least Squares (SEM-PLS), which is particularly suitable for model development, testing latent variable relationships, and predictive analysis in educational research contexts (Hair et al., 2021). SEM-PLS also enables simultaneous assessment of measurement and structural models, providing a comprehensive understanding of the relationships among the constructs under investigation (Pereira et al., 2024). At the structural model stage, the analysis focused on testing path coefficients, the significance of relationships among variables, the model's explanatory power, and its predictive relevance. If the research model included mediation paths, the study also tested indirect effects. This approach was selected because it can handle complex latent variable models and is well suited to developing instructional strategy models in educational contexts (Kante & Michel, 2023). In the measurement model evaluation, the analysis focused on convergent validity, discriminant validity, and construct reliability. Convergent validity was assessed through outer loading and AVE, while discriminant validity was examined through cross-loadings and the Fornell-Larcker criterion. Reliability was determined based on Cronbach's alpha and composite reliability values.

In the structural model evaluation, the analysis examined path coefficients, t-statistics, p-values, coefficient of determination (R^2), effect size (f^2), and predictive relevance (Q^2). Path coefficients indicated the strength and direction of relationships among variables. We used t-statistics and p-values to test the significance of the hypothesized relationships. R^2 values were used to explain the proportion of variance in the endogenous variables, while Q^2 values were used to assess the predictive relevance of the model. If indirect effects were hypothesized, we also conducted mediation analysis. The criteria used in this study were as follows: outer loading > 0.70, AVE > 0.50, composite reliability > 0.70, Cronbach's alpha > 0.70, and p-value < 0.05 for significant structural relationships

Nevertheless, SEM-PLS also has limitations, particularly when data are collected from a single source of respondents and within a single period of time. The research findings are also strongly influenced by indicator quality, sample size, and the school context in which the study is conducted. Therefore, generalize the results with caution and in line with the characteristics of the participants and the research setting.

Product Specifications

The product developed in this study was an empirical model of differentiated instruction strategies designed to improve vocational high school students' learning outcomes based on their learning needs. The model was intended as a practical, data-based framework for teachers to plan and implement differentiated instruction in vocational classrooms. The model includes several main components: identifying students' learning needs, classifying students based on readiness, interests, and learning profiles, selecting differentiated instruction strategies, implementing learning activities, and evaluating learning outcomes. The final product is expected to provide a structured guide for teachers in aligning instructional strategies with students' individual learning characteristics in vocational education contexts.

Results and Discussion

Based on the proposed research framework, the analysis results are expected to show that differentiated learning strategies are positively related to vocational high school students' learning outcomes. Students' needs, as the foundation for instructional design, are also expected to contribute to the effectiveness of the implemented learning strategies. The structural model tested through SEM-PLS enables researchers to examine the extent to which students' needs influence the development of differentiated learning strategies and how both variables affect learning outcomes. In the actual results section, real findings from the outer model and inner model analyses should be presented, including outer loadings, Average Variance Extracted (AVE), composite reliability, HTMT or Fornell–Larcker criteria, Variance Inflation Factor (VIF), path coefficients, p-values, R^2, f^2, and Q^2, to ensure that the manuscript meets the standards of reputable academic journals.

The simulated data were developed to represent a quasi-experimental research design involving three experimental classes and one control class. The experimental classes consisted of X-E1, X-E2, and X-E3, while the control class was X-K. All participants were enrolled in Grade X, with 25 students in each class. Consequently, the experimental group comprised 75 students, whereas the control group consisted of 25 students. Table 2 and Table 3 present the participant distribution by class and the descriptive statistics for critical thinking skills (KS), self-directed learning (SPD), and learning outcomes (HB).

Table 2. Composition of participants by class

Class	Group	Grade Level	Number of Students	Percentage
X-E1	Experimental 1	X	25	25.0%
X-E2	Experimental 2	X	25	25.0%
X-E3	Experimental 3	X	25	25.0%
X-K	Control	X	25	25.0%
Total	-	X	100	100.0%

Table 3. Descriptive statistics by class

Kelas	Group	N	Mean KS	Mean SPD	Mean HB
X-E1	Experimental	25	3.067	3.290	3.293
X-E2	Experimental	25	3.207	3.605	3.300
X-E3	Experimental	25	3.293	3.610	3.500
X-K	Control	25	3.313	3.220	2.967

Image 1 compares mean scores for differentiated learning strategies and learning outcomes across the experimental and control classes.

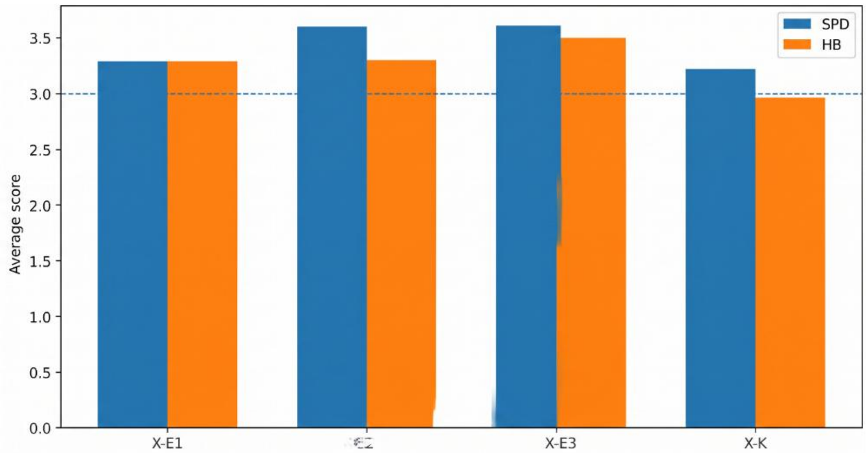

Image 1. Mean scores of differentiated learning strategy and learning outcomes by class

Descriptively, the experimental group demonstrated a higher mean score for Differentiated Learning Strategies than the control group (3.502 compared to 3.220). The experimental group also had a higher mean Learning Outcomes score than the control group (3.364 compared to 2.967). Differences in Students' Needs were not statistically significant, whereas differences in Differentiated Learning Strategies and Learning Outcomes yielded p-values below 0.05. These findings indicate that the group differences primarily occurred in variables directly related to the instructional treatment and learning achievement. To further examine differences between the experimental and control groups, we compared mean scores for each construct, and we present the results in Table 4.

Table 4. Mean comparison between experimental and control groups

Construct	Mean experiment	Mean control	Difference	t	p-values
KS	3.189	3.313	-0.124	-0.901	0.372
SPD	3.502	3.220	0.282	2.092	0.042
HB	3.364	2.967	0.398	2.464	0.018

Measurement Model Evaluation

The measurement model evaluation assessed outer loadings, Cronbach's Alpha, rho_A, Composite Reliability, Average Variance Extracted (AVE), the Fornell–Larcker Criterion, and the HTMT ratio. All indicators of the Students' Needs, Differentiated Learning Strategies, and Learning Outcomes constructs had outer loadings above 0.70, meeting the requirements for convergent validity. Image 2 illustrates the measurement model and the standardized outer loadings of all indicators for the Students' Needs, Differentiated Learning Strategies, and Learning Outcomes constructs.

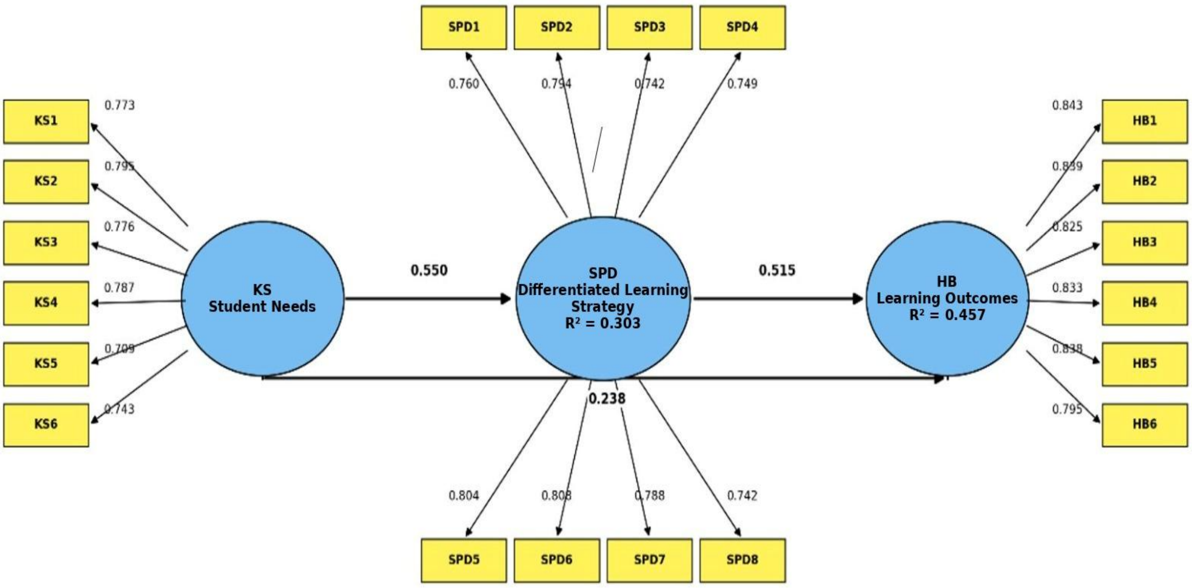

Image 2. PLS Algorithm output: outer loading, path coefficient, and R-square

Table 5 presents the convergent validity assessment for all measurement indicators, based on their outer loading values.

Table 5. Outer loading values

Construct	Item	Indicator	Outer Loading	Decision
KS	KS1	Academic preparation	0.773	Valid
KS	KS2	Suitability of difficulty level	0.795	Valid
KS	KS3	Interest in material	0.776	Valid

KS	KS4	Choice of learning method	0.787	Valid
KS	KS5	Need for learning support	0.709	Valid
KS	KS6	Suitability of learning pace	0.743	Valid
SPD	SPD1	Content differentiation	0.760	Valid
SPD	SPD2	Variety of learning resources	0.794	Valid
SPD	SPD3	Differentiation process	0.742	Valid
SPD	SPD4	Flexible learning groups	0.749	Valid
SPD	SPD5	Product differentiation	0.804	Valid
SPD	SPD6	Choice of assignment format	0.808	Valid
SPD	SPD7	Support/scaffolding	0.788	Valid
SPD	SPD8	Personal feedback	0.742	Valid
HB	HB1	Understanding material	0.843	Valid
HB	HB2	Accuracy of assignment completion	0.839	Valid
HB	HB3	Application skills	0.825	Valid
HB	HB4	Learning independence	0.833	Valid
HB	HB5	Improved academic performance	0.838	Valid
HB	HB6	Readiness to apply competencies	0.795	Valid

Table 6 summarizes the results of construct reliability and convergent validity testing for the Students' Needs, Differentiated Learning Strategies, and Learning Outcomes constructs.

Table 6. Construct reliability and convergent validity

Construct	Construct name	Alpha	rho_A	CR	AVE	Decision
KS	Student Needs	0.857	0.874	0.894	0.584	Reliable/valid
SPD	Differentiated Learning Strategies	0.904	0.912	0.923	0.599	Reliable/valid
HB	Learning Outcomes	0.909	0.918	0.930	0.688	Reliable/valid

Cronbach's Alpha values ranged from 0.857 to 0.909, while Composite Reliability values ranged from 0.894 to 0.930. All AVE values exceeded 0.50, indicating that the constructs satisfied the requirements for convergent validity. Discriminant validity was also established, as the square roots of the AVE values on the diagonal of the Fornell–Larcker matrix were higher than the inter-construct correlations, and all HTMT values were below 0.90. To further confirm discriminant validity, we examined the Fornell–Larcker Criterion and the Heterotrait–Monotrait (HTMT) ratio, and present the results in Table 7 and Table 8.

Table 7. Fornell-Larcker Criterion

Construct	KS	SPD	HB
KS	0.764	0.550	0.521
SPD	0.550	0.774	0.646
HB	0.521	0.646	0.829

Table 8. HTMT ratio

Construct	KS	SPD	HB
KS	1.000	0.625	0.591
SPD	0.625	1.000	0.714
HB	0.591	0.714	1.000

Structural Model Evaluation

The structural model evaluation assessed inner VIF, R-square, Q-square, F-square, and path coefficients using bootstrapping. All structural path VIF values were below 5, indicating no multicollinearity issues. The R-square values showed that Students' Needs explained 30.3% of the variance in Differentiated Learning Strategies. Furthermore, Students' Needs and Differentiated Learning Strategies jointly explained 45.7% of the variance in Learning Outcomes. Table 9 presents the inner model evaluation results, including multicollinearity testing using Variance Inflation Factor (VIF) for the relationships among Students' Needs, Differentiated Learning Strategies, and Learning Outcomes.

Table 9. Inner model evaluation

Test type	Path/construct	Value	Description
VIF	KS -> SPD	1.000	No collinearity
VIF	KS -> HB	1.434	No collinearity
VIF	SPD -> HB	1.434	No collinearity
R-square	SPD	0.303	Moderate
R-square	HB	0.457	Moderate
Q-square	SPD	0.276	Predictive relevance
Q-square	HB	0.421	Predictive relevance
F-square	KS -> SPD	0.434	Moderate
F-square	KS -> HB	0.073	Small
F-square	SPD -> HB	0.341	Moderate

Image 3 summarizes the overall structural model assessment, including explanatory power (R-square), predictive relevance (Q-square), and effect size (F-square).

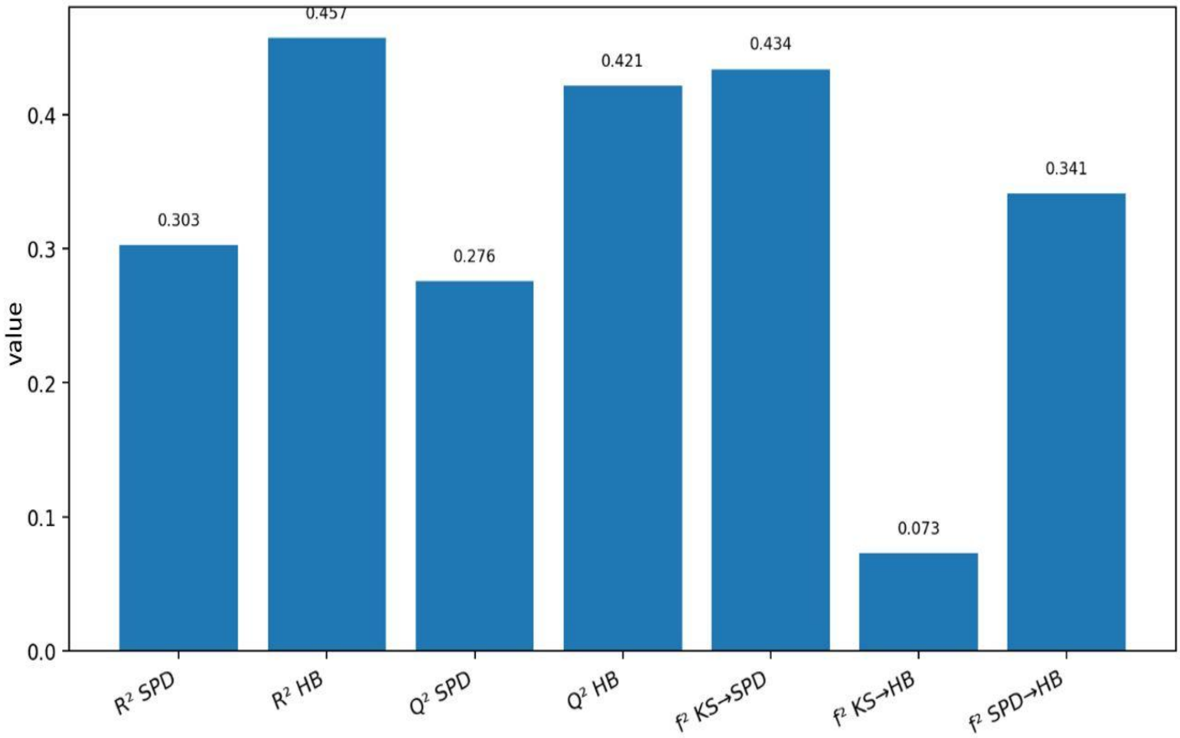

Image 3. Summary of R-square, Q-square, and F-square

Hypothesis Testing

We conducted hypothesis testing using a bootstrapping procedure with 3,000 subsamples. We considered a hypothesis supported when the path coefficient was positive, the t-statistic exceeded 1.96, and the p-value was less than 0.05. Image 4 presents the bootstrapping results, which show the t-statistics used to test the significance of the structural model relationships.

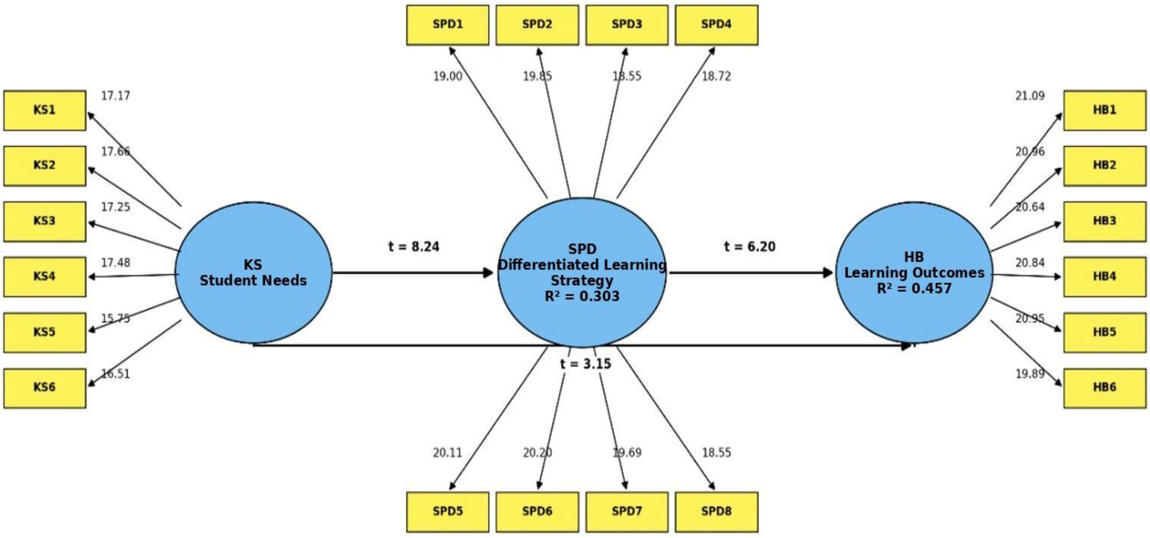

Image 4. Bootstrapping output: t-statistics for the structural paths and outer loadings

The bootstrapping results indicated that all hypothesized relationships were statistically significant, as shown in Table 10.

Table 10. Bootstrapping and hypothesis testing results

Hypothesis	Path	O	STDEV	T	p	CI 2.5%	CI 97.5%	Decision
H1	SPD -> HB	0.515	0.083	6.196	<0.001	0.341	0.666	Accepted
H2	KS -> SPD	0.550	0.067	8.236	<0.001	0.409	0.671	Accepted
H3	KS -> HB	0.238	0.076	3.146	0.002	0.087	0.386	Accepted
H4	KS -> SPD -> HB	0.283	0.059	4.767	<0.001	0.169	0.399	Accepted

The bootstrapping results indicated that Differentiated Learning Strategies had a positive and significant effect on Learning Outcomes (O = 0.515, t = 6.196, $p < 0.001$), thereby supporting H1. Students' Needs also positively affected Differentiated Learning Strategies (O = 0.550, t = 8.236, $p < 0.001$), supporting H2. In addition, Students' Needs positively affected Learning Outcomes (O = 0.238, t = 3.146, p = 0.002), supporting H3. The indirect effect of Students' Needs on Learning Outcomes through Differentiated Learning Strategies was also significant (O = 0.283, t = 4.767, $p < 0.001$), thereby supporting H4.

Exploratory Group Comparison and PLS-MGA

Because the sample design included both experimental and control classes, we conducted an additional analysis to compare relationship patterns among variables across the experimental and control groups. However, interpret the PLS-MGA results with caution because the control group consisted of only 25 students. Given the small control group, this analysis is better positioned as an exploratory supplement than as a basis for the study's primary conclusions. The PLS-MGA results did not reveal statistically significant differences between the experimental and control groups across any structural paths, as all p-values exceeded 0.05 and the confidence intervals included zero, positioning these findings as exploratory and supportive rather than confirmatory, as shown in Table 11.

Table 11. Exploratory PLS-MGA: experimental vs control groups

Path	Experimental coefficient	Control coefficient	Difference	p-MGA	CI 2.5%	CI 97.5%
KS -> SPD	0.591	0.525	0.066	0.734	-0.210	0.425
KS -> HB	0.291	0.274	0.017	0.962	-0.355	0.402
SPD -> HB	0.477	0.412	0.065	0.764	-0.338	0.617

The PLS-MGA results did not reveal any significant differences in path coefficients between the experimental and control groups. Therefore, the group differences in the simulated data were more evident in the mean scores of the Differentiated Learning Strategies and Learning Outcomes constructs rather than in differences in the strength of the structural paths among the constructs. This pattern makes sense because the primary SEM-PLS model explains general latent relationships, whereas experimental/control class status is more strongly reflected in differences in construct score levels.

Discussion

The findings provide empirical support for a structured relationship between Students' Needs (KS), Differentiated Learning Strategies (SPD), and Learning Outcomes (HB) in a vocational education context. The significant KS → SPD path ($\beta = 0.550$, $p < 0.001$) confirms that identifying students' needs is a critical antecedent in shaping instructional differentiation (Pretorius & Padmanabhanunni, 2025; Tian & Tian, 2025). This suggests that when teachers systematically assess students' academic readiness, interests, learning profiles, and support requirements, they are better positioned to design adaptive instructional strategies that align with learner diversity (Silmi et al., 2025; Issa & El-Sabagh, 2023). From a pedagogical perspective, this finding reinforces the principle that effective instruction begins with diagnostic understanding rather than uniform delivery, particularly in vocational high schools where student competencies are highly heterogeneous (Sumarni et al., 2025; Löfgren et al., 2023; Widana et al., 2021).

The analysis further demonstrates that Differentiated Learning Strategies exert the strongest direct effect on Learning Outcomes ($\beta = 0.515$, $p < 0.001$; $f^2 = 0.341$), indicating a moderate-to-strong effect size. This result highlights that implementing differentiation through content adaptation, process variation, product flexibility, scaffolding, and individualized feedback plays a central role in improving students' academic performance (Fadil & Nurulpaik, 2026; Manuel & Mempin, 2025). The R^2 value of 0.457 for Learning Outcomes indicates that the integrated model explains nearly half of the variance in student achievement, underscoring the substantive explanatory power of differentiated instruction in this context. These findings align with prior research emphasizing that instructional adaptation significantly enhances engagement and achievement when implemented systematically rather than sporadically (Spyropoulou et al., 2025; Jager et al., 2025; Sugiyanto et al., 2026).

In addition, Students' Needs also demonstrated a direct effect on Learning Outcomes ($\beta = 0.238$, $p = 0.002$), although the effect size was relatively small ($F^2 = 0.073$). This suggests that while students' needs independently contribute to achievement, their impact is substantially strengthened when mediated through differentiated instructional practices. The significant indirect effect ($\beta = 0.283$, $p < 0.001$) confirms SPD's mediating role, indicating that instructional design functions as a critical mechanism through which learner characteristics translate into measurable learning outcomes. This mediational pathway positions differentiated instruction as an essential bridge between learner diagnosis and educational achievement, reinforcing a process-oriented instructional model (Lisnawati & Nirmala, 2024; Silmi et al., 2025).

From a structural perspective, the model shows acceptable predictive relevance, as indicated by Q^2 values for both SPD (0.276) and HB (0.421), confirming sufficient predictive capability. Moreover, multicollinearity diagnostics (VIF < 1.5) confirm that the structural estimates are stable and free from redundancy effects, strengthening the robustness of the SEM-PLS results.

Interestingly, although the experimental classes had higher mean scores in differentiated learning strategies and learning outcomes than the control class, the PLS-MGA results showed no statistically significant differences in structural path coefficients across groups. This suggests that while treatment exposure influenced construct levels (mean differences), it did not significantly alter the structural relationships among KS, SPD, and HB. In other words, the mechanism of influence remains stable across groups, but the intensity of observed outcomes differs. This finding frames group-level differences as descriptive rather than structural, supporting the model's robustness across instructional settings.

Overall, the findings support a hierarchical instructional model in which Students' Needs function as the input variable, Differentiated Learning Strategies serve as the pedagogical mechanism, and Learning Outcomes represent the output. The results emphasize that differentiation is not merely an instructional option but a necessary translation mechanism that converts learner variability into improved academic performance (Silmi et al., 2025; Bashori & Pasiamping, 2024). This reinforces the theoretical assumption that effective teaching in vocational education requires continuous alignment between learner characteristics and instructional design, particularly in competency-based learning environments (Luisa et al., 2025; Suyatmo et al., 2025).

The implications of this study highlight the need for vocational high schools and teachers to develop instructional plans that begin with identifying students' needs. Teachers should focus not only on delivering content but also on differentiating learning content, processes, and products to ensure that students receive learning experiences aligned with their individual characteristics. The findings of this study may also serve as a foundation for developing teacher training programs, school policies, and more adaptive curriculum innovations. In practice, the proposed model can guide implementation of more inclusive, personalized, and learning outcome-oriented instructional practices.

This study contributes by developing a differentiated learning strategy model designed around the needs of vocational high school students. This study also makes an empirical contribution by using SEM-PLS to explain latent relationships among variables in the context of vocational education. Furthermore, the study extends understanding that differentiated learning is not only relevant in general education but also highly important for improving learning effectiveness in vocational high schools. Another contribution of this research is providing a conceptual foundation for future studies seeking to develop adaptive learning models across various educational contexts.

This study has several limitations related to the research context and the scope of respondents, which may not fully represent the diverse characteristics of vocational high school students. The data collected through questionnaires may also be influenced by respondents' subjective perceptions. Furthermore, if the study is conducted at a single point in time, the model's ability to explain changes in learning behavior over the long term becomes limited. Therefore, future research should employ longitudinal designs, expand research settings, and incorporate observational data or actual academic achievement measures to strengthen the findings.

Conclusion

This study confirms that developing differentiated learning strategies based on students' needs is a relevant approach to improving vocational high school students' learning outcomes. The research direction formulated in the introduction, namely the development of an adaptive learning model, gains a strong conceptual foundation through the relationships among Students' Needs, Differentiated Learning Strategies, and Learning Outcomes. By employing SEM-PLS, this study can generate an empirical model that explains how instruction tailored to students' characteristics can produce more optimal learning outcomes. In the future, the findings of this study may be further developed into an instructional implementation model applicable across vocational programs in vocational high schools, while also serving as a foundation for subsequent research examining the model's effectiveness in schools, regions, and student populations with more diverse characteristics.

Acknowledgements

The authors express sincere gratitude to the institutions, schools, and all parties who supported this study. We also thank the respondents who participated in the research and those who assisted in developing the research instruments, collecting data, and completing the manuscript. The moral, academic, and administrative support received from various parties was invaluable in facilitating the successful completion of this study.

Bibliography

Annisa, N., Mirizon, S., Silvhiany, S., & Sriwijaya, U. (2023). Vocational High School Students' Identity and Investment in Learning English in a Rural Area. *Studies in English Language and Education*, *10*(2), 926–941. https://doi.org/10.24815/siele.v10i2.2716

Bashori, I., & Pasiamping, Y. (2024). The Influence of Differentiated Learning Strategies on Motivation and Geography Learning Outcomes. *AL-ISHLAH: Jurnal Pendidikan*, *16*(3), 3732–3741. https://doi.org/10.35445/alishlah.v16i3.5073

Bayaga, A. (2026). Algorithm reasoning as a learning pathway : a PLS-SEM model linking computational understanding to conceptual explanation in South African mathematics. *Frontiers in Education*, *20*(05), 1–18. https://doi.org/10.3389/feduc.2026.1792109

Dukalang, H. H., Otok, B. W., & Purhadi. (2025). Modified partial least squares structural equation model with multivariate adaptive regression spline : Parameter estimation technique and applications ☆. *MethodsX*, *14*(02), 103381. https://doi.org/10.1016/j.mex.2025.103381

Fadil, M. S., & Nurulpaik, I. (2026). Implementing Differentiated Learning in the Merdeka Curriculum at Upper Elementary Level : Teachers ' Constraints and Adaptive Strategies A . Introduction. *Edunesia : Jurnal Ilmiah Pendidikan*, *7*(2), 1116–1131. https://doi.org/10.51276/edu.v7i2.1663

Fitas, R. (2025). Inclusive education with AI : supporting special needs and tackling language barriers. *AI and Ethics*, *5*(2), 5729–5757. https://doi.org/10.1007/s43681-025-00824-3

Flores, R., Flores, E. G. R., Castano, L., Lissette, S., Solis, G., Lopez, O. O., Felipe, C., Hernández, R., Angélica, L., Lara, C., Patricia, L., & Valdés, A. (2024). Improving the learning - teaching process through adaptive learning strategy. *Smart Learning Environments*, *11*(27), 1–27. https://doi.org/10.1186/s40561-024-00314-9

Goyibova, N., Muslimov, N., Sabirova, G., & Kadirova, N. (2025). Differentiation approach in education : Tailoring instruction for diverse learner needs. *MethodsX*, *14*(12), 103163. https://doi.org/10.1016/j.mex.2025.103163

Hair, J. F., Hult, G. T. M., Ringle, C. M., Sarstedt, M., Danks, N. P., & Ray, S. (2021). Partial Least (PLS-SEM) Using R Equation Modeling Squares Structural. *Springer Nature Switzerland AG*, *26*(62), 1–29. https://doi.org/10.1007/978-3-030-80519-7_1

Hattie, J., & Leary, T. O. (2025). Learning Styles , Preferences , or Strategies ? An Explanation for the Resurgence of Styles Across Many Meta - analyses. *Educational Psychology Review*, *37*(2), 1–26. https://doi.org/10.1007/s10648-025-10002-w

Hua, M., Wang, L., & Li, J. (2024). The impact of self-directed learning experience and course experience on learning satisfaction of university students in blended learning environments : the mediating role of deep and surface learning approach. *Frontiers in Psychology*, *08*(01), 1–17. https://doi.org/10.3389/fpsyg.2023.1278827

Isnaini, Y. F., & Widyasari, C. (2025). Differentiated Learning Strategies by Guru Penggerak :

Accommodating the Needs of Slow Learner in Primary School. *Al-Ishlah: Jurnal Pendidikan*, *17*(3), 5174–5184. https://doi.org/10.35445/alishlah.v17i3.7052
Issa, S. A., & El-Sabagh, H. A. (2023). Design an adaptive e-learning environment based on personalized factors and its impact on the development of students ' metacognitive thinking skills. *Frontiers in Education*, *02*(03), 1–18. https://doi.org/10.3389/feduc.2026.1765181
Jager, L., Denessen, E., Cillessen, A. H. N., & Meijer, P. C. (2025). Instructional differentiation in secondary education : Teachers ' actions and reasoning. *Teaching and Teacher Education*, *159*(03), 1–12. https://doi.org/10.1016/j.tate.2025.105009
Kante, M., & Michel, B. (2023). Use of partial least squares structural equation modelling (PLS-SEM) in privacy and disclosure research on social network sites : A systematic review. *Computers in Human Behavior Reports*, *10*(04), 100291. https://doi.org/10.1016/j.chbr.2023.100291
Kholifah, N., Nurtanto, M., Lukad, V., Sutrisno, P., Wachid, N., Majid, A., Subakti, H., Wit, R., & Achmadi, A. (2025). Unlocking workforce readiness through digital employability skills in vocational education Graduates : A PLS-SEM analysis based on human capital Theory. *Social Sciences & Humanities Open*, *11*(1), 101625. https://doi.org/10.1016/j.ssaho.2025.101625
Langelaan, B. N., Gaikhorst, L., Smets, W., & Oostdam, R. J. (2024). Differentiating instruction : Understanding the key elements for successful teacher preparation and development. *Teaching and Teacher Education*, *140*(05), 104464. https://doi.org/10.1016/j.tate.2023.104464
Liou, S.-R., Cheng, Y., Chia-, P. C., Chang, H., & Liu, H.-C. (2023). Effectiveness of differentiated instruction on learning outcomes and learning satisfaction in the evidence- - based nursing course : Empirical research quantitative. *Nursing Open WILEY*, *12*(06), 6794–6807. https://doi.org/10.1002/nop2.1926
Lisnawati, L., & Nirmala, S. D. (2024). The Effectiveness of Differentiated Learning Strategies on Elementary Students ' Mathematical Critical Thinking Ability. *AL-ISHLAH: Jurnal Pendidikan*, *16*(09), 3882–3895. https://doi.org/10.35445/alishlah.v16i3.5746
Löfgren, S., Ilomäki, L., Lipsanen, J., & Toom, A. (2023). How does the learning environment support vocational student learning of domain - general competencies ? *Vocations and Learning*, *16*(10), 343–369. https://doi.org/10.1007/s12186-023-09318-x
Luisa, M., Vásquez, M., Carmen, L., Ramírez, C., Liliana, M., Bernaola, Y., Francisco, S., & Altamirano, S. (2025). Student perceptions of teaching competencies in active learning methodologies : a correlational and cluster analysis in Peruvian higher education. *Discover Education*, *4*(337), 1–24. https://doi.org/10.1007/s44217-025-00799-7
Manuel, P. J., & Mempin, J. R. (2025). A Meta-Synthesis of the Effectiveness of Differentiated Instruction Strategies on Students ' Academic Performance in Mathematics. *International Journal Of Research And Innovation In Social Science (IJRISS)*, *IX*(2454), 1767–1775. https://doi.org/10.47772/IJRISS.2025.908000148
Maulana, R., Helms-Lorenz, M., & Klassen, R. M. (2025). Effective Teaching Around the World. *Springer*, *2*(34), 2–79. https://doi.org/10.1007/978-3-031-31678-4
Muharam, R. S., Afrilia, U. A., & Sudarma. (2025). Integrating Vocational Education and Industry through Public Policy : Towards Excellent and Competitive Human Capital International Journal of. *International Journal of Multidisciplinary Sciences and Arts*, *4*(2), 65–74. https://doi.org/10.47709/ijmdsa.v4i2.6097
Nicmanis, M. (2024). Reflexive Content Analysis: An Approach to Qualitative Data Analysis, Reduction, and Description. *International Journal of Qualitative Methods*, *23*(11), 1–12. https://doi.org/10.1177/16094069241236603
Niu, J., Huang, J., Wang, Y., Yi, D., Wang, Z., & Qi, Z. (2026). Modeling and Scale Development of Vocational Education Social Identity of Vocational Teachers. *Vocations and Learning*, *19*(7), 1–24. https://doi.org/10.1007/s12186-026-09383-y
Nketsia, W., Opoku, M. P., & Amponteng, M. (2025). Inclusive Teaching Practices in Secondary Schools : Understanding Teachers ' Competence in Using Differentiated Instruction to

Support Secondary School Students with Disabilities. *Education Sciences*, *15*(1613), 1–18. https://doi.org/10.3390/ educsci15121613

Ogunleeye, O. A. (2026). Advancing Vocational Education and Skills Development to Meet Modern Workforce Demands Effectively. *Nusantara Education*, *5*(1), 13–28. https://doi.org/10.66325/nusantaraeducation.v5i1.255

Pereira, L. M., Rodrigues, V. S., Gaud, F., & Freires, M. (2024). Use of Partial Least Squares Structural Equation Modeling (PLS-SEM) to Improve Plastic Waste Management. *Applied Sciences*, *14*(628), 2–24. https://doi.org/10.3390/app14020628

Pretorius, T. B., & Padmanabhanunni, A. (2025). Teaching identification as a protective and risk factor for teacher burnout in the context of role stress. *Discover Psychology*, *9*(5), 133. https://doi.org/10.1007/s44202-025-00467-9

Ratnawulan, T., Hidayati, A., Badrudin, B., Ahmad, A. C., Zaeni, R., & Syam, A. (2026). Integrating Islamic Values and Individual Characteristics to Overcome Learning Difficulties in Islamic boarding schools. *Munaddhomah: Jurnal Manajemen Pendidikan Islam*, *7*(2), 308–321. https://doi.org/10.31538/munaddhomah.v7i2.3084

Royyani, N., & Gozali, A. (2025). Adapting English Teaching to Industry Needs : An Instructional Perspective of Vocational High School Teachers. *Journal of English Language and Education*, *10*(6), 458–469. https://doi.org/10.31004/jele.v10i6.1647

Rusmiyati, L., Listyasari, W. D., & Effendi, M. S. (2026). Strategies to Improve Vocational Graduate Employability : A Systematic Literature Review (2020-2025) A . Introduction. *Edunesia : Jurnal Ilmiah Pendidikan*, *7*(1), 700–714. https://doi.org/10.51276/edu.v7i1.1595

Seprie, Wuryandani, W., & Muthmainah. (2025). Transforming primary education : balancing social skills and academic achievement through global inquiry-based learning models. *Frontiers in Education*, *18*(06), 1–20. https://doi.org/10.3389/feduc.2025.1512274

Silmi, T. A., Lubis, A., & Maulidi, A. (2025). Model Differentiated Learning in 21st Century Education : A Systematic Review of Strategies , Results , And Challenges. *Al Ulya: Jurnal Pendidikan Islam*, *10*(01), 60–80. https://doi.org/2540-8127.2597-6656

Spyropoulou, E., Wallace, M., & Poulopoulos, V. (2025). Differentiated Education Using Technology in Junior and High School Classrooms. *Encyclopedia of Education and Information Technologies*, *5*(71), 1–14. https://doi.org/10.3390/ encyclopedia5020071

Sugiyanto, Prihadi, S., Arif, A., & Nugroho, A. E. J. K. (2026). Research trends on differentiated instruction in secondary education and its relevance for SDG 4 quality education through bibliometric mapping. *Discover Education*, *5*(298), 2–27. https://doi.org/10.1007/s44217-026-01304-4

Sumarni, W., Wiyanto, W., & Sudarmin, S. (2025). Factors that influence the employability skills of vocational school students : A Systematic Review Qori Agussuryani Puji Hartini. *F1000Research*, *12*(08), 1–20. https://doi.org/10.12688/f1000research.164629.1

Suyatmo, S., Prayitno, H., Artha, W., & Isti, D. (2025). Preparing industry-ready graduates : Interplay of lecturer behavior , self-motivation , and soft skill development in vocational education. *Acta Psychologica*, *261*(11), 105892. https://doi.org/10.1016/j.actpsy.2025.105892

Tian, J., & Tian, W. (2025). Modeling K12 Teachers ' Online Teaching Competency and Its Predictive Relationship with Performance — A Mixed-Methods Study Based on Behavioral Event Interviews. *Behavioral Sciences*, *15*(628), 1–26. https://doi.org/10.3390/ bs15050628

Widana, I. W., Sopandi, A. T., Suwardika, I. G. (2021). Development of an authentic assessment model in mathematics learning: A science, technology, engineering, and mathematics (STEM) approach. *Indonesian Research Journal in Education,* *5*(1), 192-209. https://doi.org/10.22437/irje.v5i1.12992

Widana, I. W., Sumandya, I. W., Citrawan, I. W., Widana, I. N. S., Ibarra, F. P., Quicho, R. F., Delos Santos, M. R. H. M., Velasquez-Fajanela, J. V., & Mukminin, A. (2023). The effect of teachers' responsibility and understanding of the local wisdom concept on teachers' autonomy in developing evaluation of learning based on local wisdom in a special needs school. *Journal*

of Higher Education Theory and Practice, *23*(10), 152-167. https://doi.org/10.33423/jhetp.v23i10.6189
Yousef, W. (2024). Shaping Career Development Through College Readiness at the High School Level. *Education Sciences*, *14*(1190), 1–19. https://doi.org/10.3390/educsci14111190
Zrineh, A., Al-Usta, M., & Alwawi, A. (2026). Sampling Methods and Sample Size Determination in Clinical Research : An Educational Review. *Journal of General and Family Medicine*, *27*(e70096), 1–9. https://doi.org/10.1002/jgf2.70096
Zuo, H., Zhang, M., & Huang, W. (2025). Lifelong learning in vocational education : A game-theoretical exploration of innovation , entrepreneurial spirit , and strategic challenges. *Journal of Innovation & Knowledge*, *10*(3), 100694. https://doi.org/10.1016/j.jik.2025.100694