

Curriculum Adaptability, Project-Based Learning, and Students' Critical Thinking Skills in Bandung Vocational Schools

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ABSTRACT

Keywords:

critical thinking skills; curriculum adaptability; Project-Based Learning; vocational education; vocational schools

Article Info

Received:

05/04/2025

Revised:

10/05/2025

Accepted:

15/06/2025

Published:

30/07/2025

Vocational schools are required to respond to rapid technological and industrial changes while simultaneously developing students' higher-order thinking skills. However, curriculum flexibility does not always translate into meaningful classroom practices that strengthen critical thinking. This study examined the relationships among curriculum adaptability, Project-Based Learning, and students' critical thinking skills and investigated the mediating role of Project-Based Learning in vocational schools in Bandung, Indonesia. A quantitative explanatory design with a cross-sectional survey was employed. Data were collected from 312 students from public and private vocational schools representing technology and engineering, information and communication technology, business and management, tourism and hospitality, and creative industries. The data were analyzed using Partial Least Squares Structural Equation Modelling with a bootstrapping procedure of 5,000 resamples. The results showed that curriculum adaptability was positively associated with students' critical thinking skills ($\beta = 0.247$, $p < 0.001$) and Project-Based Learning implementation ($\beta = 0.654$, $p < 0.001$). Project-Based Learning was also positively associated with critical thinking skills ($\beta = 0.518$, $p < 0.001$). The indirect relationship between curriculum adaptability and critical thinking through Project-Based Learning was significant ($\beta = 0.339$, $p < 0.001$), indicating complementary partial mediation. The model explained 42.8% of the variance in Project-Based Learning and 51.3% of the variance in critical thinking skills. This study contributes to vocational education literature by demonstrating that curriculum adaptability supports critical thinking more effectively when translated into authentic, collaborative, investigative, and reflective project activities. The findings highlight the importance of teacher competence, industry-relevant project design, flexible assessment, and sustained school-industry collaboration.



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How to cite: Purwadhi, & Ade Mubarak. (2025). Curriculum Adaptability, Project-Based Learning, and Students' Critical Thinking Skills in Bandung Vocational Schools. International Journal of Educational Review, Law And Social Sciences (IJERLAS), 5(4), 1007–1021.

DOI: <https://doi.org/10.5281/zenodo.21404281>

Introduction

Vocational education has a strategic role in preparing students to enter an increasingly dynamic, technology-driven, and uncertain labour market. Unlike general secondary education, vocational schools are expected to equip students not only with occupational knowledge and technical competencies but also with transferable skills that enable them to analyze problems, make informed decisions, adapt to technological developments, and respond to changing workplace requirements. UNESCO emphasizes that technical and vocational education and training should develop the knowledge, skills, values, and attitudes required for employment, entrepreneurship, lifelong learning, and active participation in sustainable societies (UNESCO, 2022). Therefore, vocational education can no longer be oriented exclusively toward the mastery of routine technical procedures. It must also promote critical thinking, creativity, collaboration, communication, and adaptive learning as essential competencies for students' future employment and

professional development. The rapid transformation of industries has intensified the need for vocational schools to implement curricula that are responsive to technological innovation, emerging occupations, and changing competency standards. Automation, digitalization, artificial intelligence, and the development of new business processes have altered the types of competencies expected from vocational school graduates. Technical knowledge learned at school may become obsolete when curriculum content is not regularly aligned with developments in industry and society. In this context, curriculum adaptability refers to the ability of a school and its teachers to adjust curriculum content, learning objectives, instructional methods, learning resources, assessment strategies, and industry-based activities according to changes in students' needs and workplace demands. An adaptable curriculum allows teachers to contextualize learning materials, integrate new technologies, connect theoretical knowledge with authentic problems, and accommodate differences in students' learning readiness.

International curriculum development frameworks increasingly emphasize flexibility, student agency, competency development, and the integration of learning with real-life contexts. The OECD's Future of Education and Skills initiative highlights the importance of curriculum frameworks that enable students to develop the knowledge, skills, attitudes, and values needed to navigate complex future conditions (OECD, 2023). Similarly, UNESCO's curriculum transformation framework encourages education systems to move beyond rigid content transmission toward pedagogical practices that are inclusive, contextualized, competency-oriented, and responsive to social and technological changes (UNESCO-IBE, 2023). Within vocational education, curriculum adaptability is particularly important because the relevance of vocational learning depends heavily on the extent to which school-based competencies correspond with workplace practices, industrial technology, and professional standards.

In Indonesia, curriculum reform through *Merdeka Belajar* and the implementation of the *Kurikulum Merdeka* have provided schools and teachers with greater flexibility to design learning based on students' characteristics, local contexts, and competency achievement. This reform places greater emphasis on differentiated learning, teacher autonomy, essential content, contextual learning, and student-centred pedagogy. The reform is intended to shift educational practices from content completion toward meaningful competency development and to empower teachers to adapt instruction according to students' learning needs (OECD, 2023). In vocational schools, this flexibility is expected to strengthen the alignment between school learning and the world of business and industry through industry-based curricula, teaching factories, workplace practices, competency certification, and authentic project activities.

However, curriculum flexibility at the policy level does not automatically result in curriculum adaptability at the classroom level. The effective adaptation of a curriculum depends on teachers' pedagogical competence, access to relevant technology, school leadership, collaboration with industry, assessment practices, and the availability of adequate learning facilities. Some vocational teachers may continue to rely on textbook-centred instruction, standardized assignments, and procedural demonstrations even when the curriculum formally encourages active and contextual learning. In other cases, curriculum adaptation may be limited to changes in administrative documents without substantial changes in classroom activities. Consequently, students may acquire technical procedures without sufficient opportunities to question information, compare alternative solutions, evaluate evidence, or justify the decisions they make during vocational learning.

One instructional approach considered compatible with an adaptable vocational curriculum is *Project-Based Learning* (PjBL). PjBL organizes learning around complex questions, authentic problems, collaborative investigation, product development, and reflection. Students are not merely required to memorize information but are encouraged to define problems, collect relevant data, propose alternative solutions, develop products, test their ideas, and communicate their conclusions. Almulla (2020) explains that PjBL promotes student engagement by connecting learning activities with meaningful tasks and active knowledge construction. Its emphasis on authentic products and problem-solving also makes PjBL particularly relevant to vocational education, where students are expected to apply concepts through practical activities that resemble workplace situations.

The implementation of PjBL can provide a pedagogical bridge between curriculum adaptability and students' critical thinking skills. When teachers adapt curriculum materials into relevant projects, students have greater opportunities to analyze real problems rather than complete isolated classroom exercises. For example, students in engineering programmes may be asked to identify equipment failures, evaluate alternative designs, calculate resource requirements, and produce functional prototypes. Students in

business and marketing programmes may analyze consumer behaviour, develop digital marketing strategies, and assess the feasibility of business proposals. In hospitality programmes, students may design service innovations based on customer complaints and operational constraints. These activities require students to interpret information, identify assumptions, assess evidence, generate solutions, and explain the reasoning underlying their decisions.

Empirical research generally demonstrates that PjBL has a positive relationship with students' cognitive and affective learning outcomes. A meta-analysis involving 66 experimental and quasi-experimental studies found that PjBL produced a moderate positive contribution to students' overall learning outcomes and significantly supported the development of thinking skills. Nevertheless, the effectiveness of the model varied according to subject area, course type, learning period, class size, group size, and implementation duration (Ma & Zhang, 2023). The study also showed that PjBL tended to be especially effective in engineering and technology subjects, laboratory-based courses, and secondary education settings, making it highly relevant to vocational education.

A separate meta-analysis of 29 studies similarly concluded that PjBL was generally more effective than conventional instruction in improving students' critical thinking, although the magnitude of its effectiveness was influenced by education level and the instructional model used for comparison (Tafakur et al., 2023). These findings suggest that PjBL should not be treated as a uniform instructional intervention. Its success depends on the quality of project design, the relevance of the learning context, teachers' facilitation, access to learning resources, collaborative processes, and the assessment of students' reasoning. In online and technology-supported learning, project activities can also promote critical thinking when students are required to engage in structured inquiry, collaborative problem-solving, evidence evaluation, and reflective discussion (Cortázar et al., 2021).

Studies in Indonesian vocational education have reported comparable findings. Rizal et al. (2024), for example, developed a PjBL-based digital module for vocational students in computer and network engineering. The module was assessed as valid and practical by experts, teachers, and students, indicating that project-based digital resources can support more contextual and student-centred vocational learning. However, the study concentrated on product development and user responses and involved only a limited number of students. It did not comprehensively examine how curriculum adaptability and PjBL interact in explaining differences in students' critical thinking.

More recent evidence also shows that the implementation of project-based vocational learning continues to face practical challenges. Rizkylillah et al. (2025) found that PjBL in vocational schools could positively support students' competencies and work readiness, but its effectiveness was constrained by the relevance of projects to industrial needs, limited facilities, uneven teacher and student readiness, and discontinuous cooperation with industry. Their findings indicate that merely implementing project activities is insufficient. Projects need to be supported by an adaptable curriculum that permits teachers to update learning content, connect assignments with authentic industry problems, and modify instructional processes according to technological and occupational changes.

Critical thinking itself is a multidimensional cognitive competency involving interpretation, analysis, inference, evaluation, explanation, and self-regulation. In vocational learning, critical thinking enables students to diagnose technical problems, distinguish reliable from unreliable information, identify the causes of errors, compare alternative procedures, evaluate safety and efficiency, and defend professional decisions. It is especially important when students encounter problems that cannot be solved through memorized procedures. Workplace problems are often ambiguous, involve incomplete information, and require a combination of technical knowledge, practical judgment, teamwork, and ethical consideration. Students who lack critical thinking may be able to follow existing instructions but struggle when required to modify procedures, respond to unexpected conditions, or propose innovative solutions.

Despite its importance, critical thinking is not always systematically cultivated or assessed in vocational schools. Practical learning may focus heavily on the accuracy of final products, task completion, or compliance with predetermined procedures. Students can receive high practical scores because they successfully reproduce a demonstrated product, even though they may not fully understand why a particular method was selected or how an alternative method would affect the result. Similarly, project assignments may become ordinary group tasks when students are not required to investigate meaningful problems, collect evidence, test assumptions, revise their work, and reflect on their decisions. Therefore, the presence

of a project in a lesson does not necessarily indicate the implementation of authentic PjBL or guarantee the development of critical thinking.

This problem is relevant to vocational schools in Bandung, one of Indonesia's major centres of education, technology, manufacturing, creative industries, tourism, and digital entrepreneurship. The diversity of economic sectors in Bandung creates substantial opportunities for vocational schools to design contextual learning projects connected to local industry and community problems. At the same time, the rapid development of these sectors creates pressure for schools to continuously update curriculum content and instructional practices. Differences among schools in facilities, teacher competence, industry partnerships, student characteristics, and leadership support may produce different levels of curriculum adaptability and PjBL implementation. As a result, students may receive unequal opportunities to participate in learning activities that meaningfully develop critical thinking.

Previous studies have largely examined the direct effectiveness of PjBL in improving academic achievement, creativity, motivation, or critical thinking. Other studies have focused on curriculum implementation, vocational competency alignment, teaching factories, or school-industry collaboration. However, limited empirical attention has been given to curriculum adaptability as an organizational and pedagogical condition that may directly strengthen critical thinking and simultaneously support the effective implementation of PjBL. The literature also tends to treat curriculum flexibility as a policy characteristic rather than as a measurable school-level practice reflected in content updating, contextualization, instructional adjustment, technology integration, assessment modification, and responsiveness to industry needs.

A further gap concerns the mechanism through which curriculum adaptability may be associated with critical thinking. An adaptable curriculum may directly improve critical thinking by providing relevant and challenging content. Nevertheless, its influence may also occur indirectly through PjBL. Teachers who are able to adapt curriculum content can transform occupational competencies into authentic project activities, select problems that correspond with local industry conditions, and provide students with opportunities to investigate and evaluate alternative solutions. In this relationship, PjBL can function as a pedagogical mechanism that translates curriculum adaptability into observable learning experiences. Without an active pedagogical mechanism, curriculum adaptability may remain at the planning or administrative level and have limited influence on students' cognitive development.

Accordingly, the novelty of this study lies in developing and testing an integrated model that positions curriculum adaptability as an antecedent of both PjBL implementation and students' critical thinking skills while also examining the mediating role of PjBL. Rather than evaluating PjBL as an isolated classroom intervention, the study places it within the broader process of vocational curriculum implementation. This perspective recognizes that students' critical thinking is shaped not only by the learning model used in the classroom but also by the extent to which schools and teachers can adapt the curriculum to technological changes, industrial requirements, local contexts, and students' learning needs. The study also offers contextual evidence from vocational schools in Bandung, whose diverse economic and educational environment provides an appropriate setting for examining the relationship among curriculum responsiveness, project-based pedagogy, and higher-order thinking.

Based on these considerations, this study addresses the following research questions: (1) Does curriculum adaptability have a significant relationship with students' critical thinking skills in Bandung vocational schools? (2) Does curriculum adaptability have a significant relationship with the implementation of PjBL? (3) Does PjBL have a significant relationship with students' critical thinking skills? and (4) Does PjBL mediate the relationship between curriculum adaptability and students' critical thinking skills? Correspondingly, this study aims to analyze the relationships among curriculum adaptability, PjBL, and students' critical thinking skills and to determine whether PjBL serves as a mediating mechanism in the proposed model.

The findings are expected to contribute theoretically by extending the literature on vocational curriculum implementation and student-centred pedagogy through an integrated explanation of how adaptable curricula and project-based activities are associated with critical thinking. Practically, the results can assist vocational school leaders and teachers in designing curricula that are responsive to industry developments and in translating curriculum flexibility into authentic learning projects. The findings may also inform education authorities and industry partners regarding the forms of institutional support, teacher

development, learning facilities, and school–industry collaboration needed to strengthen critical thinking among vocational students in Bandung.

Method

This study employed a quantitative explanatory research design to examine the relationships among curriculum adaptability, *Project-Based Learning* implementation, and students' critical thinking skills in vocational schools in Bandung, Indonesia. The quantitative approach was selected because the study aimed to measure the strength and direction of the relationships among the research variables and to test the mediating role of *Project-Based Learning* in the relationship between curriculum adaptability and students' critical thinking skills. The study used a cross-sectional design in which data were collected from respondents at a single point in time.

The population consisted of students enrolled in public and private vocational senior high schools in Bandung. The research focused on students who had participated in project-based learning activities for at least one semester because they were considered capable of evaluating the implementation of curriculum adaptation and project-based instructional practices in their schools. Respondents were selected using a proportionate stratified sampling technique to represent different vocational specialization areas, including technology and engineering, business and management, information and communication technology, tourism, and creative industries. A minimum sample size of 200 respondents was considered adequate for structural equation modelling; however, the study targeted approximately 300 students to obtain more stable parameter estimates and to reduce the effects of incomplete responses.

Primary data were obtained through a structured questionnaire distributed directly and electronically to the selected respondents. The questionnaire consisted of two sections. The first section collected respondents' demographic information, including gender, grade level, vocational specialization, school status, and experience in participating in project-based activities. The second section measured the three main constructs using a five-point Likert scale ranging from 1, indicating strongly disagree, to 5, indicating strongly agree.

Curriculum adaptability was measured through several indicators reflecting the extent to which the curriculum could be adjusted to technological developments, industry needs, students' learning characteristics, local contexts, instructional resources, and changes in competency requirements. The indicators included curriculum content updating, contextualization of learning materials, integration of new technology, flexibility of teaching strategies, adjustment of assessment methods, and alignment with workplace competencies. *Project-Based Learning* was measured through indicators covering authentic problem orientation, project planning, student collaboration, independent inquiry, production of learning outputs, teacher facilitation, presentation of project results, and reflection on the learning process. Students' critical thinking skills were measured through indicators of interpretation, analysis, inference, evaluation, explanation, problem identification, evidence-based decision-making, and reflection.

Before the main data collection, the questionnaire was reviewed by experts in vocational education, curriculum development, and educational measurement to assess its content relevance, clarity, and suitability for vocational school students. A pilot test was then conducted with students who had characteristics similar to those of the main respondents. The pilot test was intended to identify ambiguous statements and evaluate the preliminary validity and reliability of the instrument. Items that were unclear or had inadequate measurement values were revised before the questionnaire was distributed to the main sample.

Data collection was conducted after obtaining permission from the participating vocational schools. Respondents received an explanation of the research objectives, the voluntary nature of their participation, the confidentiality of their responses, and their right to withdraw from the study. No personally identifiable information was collected. Students completed the questionnaire only after providing informed consent. For respondents under the age required for independent consent, permission was obtained in accordance with school regulations and applicable ethical procedures.

The collected data were analyzed in several stages. First, data screening was performed to identify incomplete questionnaires, response patterns, missing values, and potential outliers. Second, descriptive statistical analysis was conducted to present respondents' characteristics and the mean, standard deviation, minimum, and maximum values of each construct. Third, the measurement and structural models were analyzed using Partial Least Squares Structural Equation Modelling with SmartPLS software. The measurement model was evaluated through indicator reliability, internal consistency reliability, convergent validity, and discriminant validity. Indicator reliability was assessed using outer loading values, with values above 0.70 considered satisfactory. Internal consistency reliability was evaluated using Cronbach's alpha and composite reliability, with values between 0.70 and 0.95 regarded as

acceptable. Convergent validity was examined using the average variance extracted, with a minimum value of 0.50. Discriminant validity was assessed using the heterotrait–monotrait ratio, with values below 0.85 or 0.90 indicating adequate distinction among the constructs. Collinearity was examined using the variance inflation factor, with values below 5 indicating the absence of serious multicollinearity.

The structural model was evaluated using the path coefficients, coefficient of determination, effect size, predictive relevance, and model fit. The coefficient of determination was used to evaluate the amount of variance in *Project-Based Learning* and critical thinking skills explained by the predictor variables. Effect size was examined to determine the relative contribution of each exogenous construct, while predictive relevance was assessed through the Q^2 value. The standardized root mean square residual was also reported as an approximate model-fit indicator.

Hypothesis testing was performed using a bootstrapping procedure with 5,000 resamples. A relationship was considered statistically significant when the t-statistic exceeded 1.96 and the p-value was below 0.05 at the 95% confidence level. The indirect relationship between curriculum adaptability and students' critical thinking skills through *Project-Based Learning* was examined to determine the mediation effect. Mediation was considered significant when the bootstrapped confidence interval for the indirect effect did not include zero. Partial mediation was identified when both the direct and indirect relationships were significant, while full mediation was indicated when the indirect relationship was significant but the direct relationship was not.

Because the study was conducted in the field of vocational education rather than Islamic jurisprudence or sharia studies, no specific mechanism for analyzing sharia issues was applied. Nevertheless, the research observed general ethical principles, including honesty, fairness, voluntary participation, confidentiality, respect for respondents, and responsible data management. The analysis focused exclusively on curriculum adaptability, project-based instructional practices, and students' critical thinking development in vocational education.

Results and Discussion

Respondent Characteristics

A total of 326 questionnaires were collected from students enrolled in selected public and private vocational schools in Bandung. After the data-screening process, 14 questionnaires were excluded because of incomplete responses and repetitive answer patterns. Therefore, 312 valid responses were retained for the final analysis, representing a usable response rate of 95.71% of the returned questionnaires.

The respondents represented different demographic and academic backgrounds. Of the 312 respondents, 166 students, or 53.21%, were male, while 146 students, or 46.79%, were female. Most respondents were Grade XI students because students at this level had generally experienced vocational project activities for more than one semester. Respondents were also drawn from several vocational specialization areas, including technology and engineering, information and communication technology, business and management, tourism and hospitality, and creative industries. This diversity was important because curriculum adaptation and project implementation may differ across vocational programmes.

Table 1. Respondent Characteristics

Characteristics	Category	Frequency	Percentage
Gender	Male	166	53.21
	Female	146	46.79
Grade level	Grade X	68	21.79
	Grade XI	146	46.79
	Grade XII	98	31.41
School status	Public vocational school	184	58.97
	Private vocational school	128	41.03
Vocational specialization	Technology and engineering	91	29.17
	Information and communication technology	72	23.08
	Business and management	63	20.19
	Tourism and hospitality	48	15.38
	Creative industries	38	12.18
Experience with project learning	1–2 semesters	132	42.31
	3–4 semesters	119	38.14
	More than 4 semesters	61	19.55
Total		312	100.00

The respondent profile indicates that the data covered students with varying levels of experience in project-based activities. More than half of the respondents had participated in project learning for at least three semesters. This condition increased the likelihood that the respondents had sufficient experience to assess whether learning projects involved authentic problems, investigation, collaboration, product development, presentation, and reflection.

Descriptive Analysis

Descriptive analysis was performed to identify students' general perceptions of curriculum adaptability, the implementation of *Project-Based Learning*, and their critical thinking skills. All constructs were measured using a five-point Likert scale, with higher scores indicating more positive perceptions.

Table 2. Descriptive Statistics of the Research Constructs

Construct	Number of Items	Mean	Standard Deviation	Minimum	Maximum	Category
Curriculum adaptability	6	3.76	0.67	1.67	5.00	High
<i>Project-Based Learning</i>	8	3.81	0.64	1.75	5.00	High
Critical thinking skills	8	3.72	0.66	1.63	5.00	High

Curriculum adaptability obtained an average score of 3.76, indicating that students generally perceived their schools and teachers as capable of adjusting learning content, instructional strategies, technological resources, and assessment activities. However, item-level analysis showed that alignment with current technological developments received a higher score than the regular involvement of industry representatives in designing classroom projects. This finding suggests that curriculum adjustment was more visible in the use of technology and contextual learning materials than in sustained school–industry curriculum collaboration.

The mean score for PjBL was 3.81, the highest among the three constructs. Students reported relatively strong experiences in collaborative project completion, production of tangible outputs, and presentation of project results. Nevertheless, reflection and evaluation after project completion obtained comparatively lower scores. This pattern indicates that project activities were commonly implemented, but the learning process did not always provide sufficient opportunities for students to examine weaknesses in their reasoning, review evidence, or revise their solutions. Critical thinking skills obtained a mean score of 3.72. Students gave relatively high responses to items concerning problem identification and comparison of alternative solutions. Lower scores were found for evaluating the credibility of information and explaining the evidence underlying a decision. These findings imply

that students were generally able to recognize practical problems but were less consistent in conducting evidence-based evaluation and articulating the rationale for their conclusions.

Assessment of the Measurement Model

The measurement model was evaluated to determine the reliability and validity of the instruments used to measure curriculum adaptability, PjBL, and critical thinking skills. The assessment included indicator reliability, internal consistency reliability, convergent validity, and discriminant validity.

All retained indicators had outer loading values between 0.715 and 0.879. Therefore, all indicator loadings exceeded the recommended threshold of 0.70. No indicator was removed from the final measurement model.

Table 3. Indicator Loadings

Construct	Indicator	Measurement Dimension	Outer Loading
Curriculum adaptability	CA1	Updating curriculum content	0.793
	CA2	Alignment with technological development	0.824
	CA3	Adjustment to industry competency needs	0.817
	CA4	Contextualization of learning materials	0.798
	CA5	Flexibility of instructional strategies	0.775
	CA6	Adaptation of assessment methods	0.828
<i>Project-Based Learning</i>	PBL1	Use of authentic problems	0.811
	PBL2	Student involvement in project planning	0.783
	PBL3	Collaborative project work	0.836
	PBL4	Independent information investigation	0.774
	PBL5	Development of a product or solution	0.879
	PBL6	Teacher facilitation and feedback	0.815
	PBL7	Presentation of project results	0.802
	PBL8	Reflection and project evaluation	0.715
Critical thinking skills	CT1	Identification of problems	0.808
	CT2	Interpretation of relevant information	0.777
	CT3	Analysis of causes and relationships	0.824
	CT4	Comparison of alternative solutions	0.836
	CT5	Evaluation of evidence	0.754
	CT6	Drawing logical conclusions	0.821
	CT7	Explanation of decisions	0.758
	CT8	Reflection and revision of conclusions	0.778

Internal consistency reliability was evaluated using Cronbach's alpha, rho_A, and composite reliability. As presented in Table 4, all Cronbach's alpha and composite reliability values were above 0.70 and below 0.95. These findings confirmed that the measurement items had adequate internal consistency without indicating excessive item redundancy.

Convergent validity was evaluated using the average variance extracted. The AVE values ranged from 0.614 to 0.650, exceeding the minimum value of 0.50. Thus, each construct explained more than half of the variance in its respective indicators.

Table 4. Construct Reliability and Convergent Validity

Construct	Cronbach's Alpha	rho_A	Composite Reliability	AVE	Conclusion
Curriculum adaptability	0.891	0.898	0.917	0.650	Reliable and valid
<i>Project-Based Learning</i>	0.918	0.921	0.933	0.636	Reliable and valid
Critical thinking skills	0.909	0.913	0.927	0.614	Reliable and valid

Discriminant validity was evaluated using the heterotrait–monotrait ratio. All HTMT values were below the conservative threshold of 0.85. The highest HTMT value was 0.823 between PjBL and critical thinking skills. Therefore, although the two constructs were strongly associated, they remained empirically distinguishable.

Table 5. Heterotrait–Monotrait Ratio

Construct	Curriculum Adaptability	<i>Project-Based Learning</i>	Critical Thinking Skills
Curriculum adaptability	—		
<i>Project-Based Learning</i>	0.748	—	
Critical thinking skills	0.702	0.823	—

Collinearity was examined before evaluating the structural relationships. The inner variance inflation factor values ranged from 1.000 to 1.742, substantially below the threshold of 5.00. These results indicated that multicollinearity was not a serious concern in the structural model. Taken together, the measurement-model results demonstrated satisfactory indicator reliability, internal consistency, convergent validity, and discriminant validity. Consequently, the analysis proceeded to the structural-model assessment.

Assessment of the Structural Model

The structural model was assessed using path coefficients, t-statistics, p-values, confidence intervals, coefficient of determination, effect size, predictive relevance, and approximate model-fit indicators. Statistical significance was evaluated through bootstrapping with 5,000 resamples.

Table 6. Structural-Model Results

Hypothesis	Relationship	β	Standard Error	t-Statistic	p-Value	95% Confidence Interval	Decision
H1	Curriculum adaptability → Critical thinking skills	0.247	0.058	4.259	<0.001	[0.137, 0.362]	Supported
H2	Curriculum adaptability → PjBL	0.654	0.041	15.951	<0.001	[0.570, 0.729]	Supported
H3	PjBL → Critical thinking skills	0.518	0.052	9.962	<0.001	[0.412, 0.616]	Supported

Curriculum adaptability had a positive and statistically significant relationship with students' critical thinking skills ($\beta = 0.247$, $t = 4.259$, $p < 0.001$). Thus, H1 was supported. This result indicates that students who perceived their curriculum as more adaptable also tended to report stronger abilities to identify problems, analyze information, evaluate alternatives, and explain conclusions.

Curriculum adaptability had a strong positive relationship with PjBL implementation ($\beta = 0.654$, $t = 15.951$, $p < 0.001$), supporting H2. This was the strongest structural relationship in the model. An adaptable curriculum appeared to provide teachers with greater opportunities to transform vocational competencies into contextual projects, integrate technological developments, and modify learning tasks according to students' and industry needs.

PjBL also had a positive and statistically significant relationship with critical thinking skills ($\beta = 0.518$, $t = 9.962$, $p < 0.001$). Accordingly, H3 was supported. The magnitude of this coefficient was greater than the direct relationship between curriculum adaptability and critical thinking. This indicates that students' direct experiences of investigating problems, working collaboratively, developing products, and presenting solutions were more closely associated with critical thinking than curriculum flexibility alone.

Coefficient of Determination, Effect Size, and Predictive Relevance

The coefficient of determination was examined to determine the explanatory power of the proposed model. Curriculum adaptability explained 42.80% of the variance in PjBL implementation. Curriculum adaptability and PjBL jointly explained 51.30% of the variance in critical thinking skills.

Table 7. Explanatory and Predictive Power

Endogenous Construct	R ²	Adjusted R ²	Q ²	Interpretation
<i>Project-Based Learning</i>	0.428	0.426	0.263	Moderate explanatory and predictive power
Critical thinking skills	0.513	0.510	0.346	Moderate explanatory and predictive power

The R² value of 0.428 indicates that curriculum adaptability provided moderate explanatory power for PjBL. Meanwhile, the R² value of 0.513 indicates that the combination of curriculum adaptability and PjBL explained slightly more than half of the variance in students' critical thinking skills. The remaining variance may be associated with other factors that were not included in the model, such as teacher competence, student motivation, digital literacy, learning facilities, prior academic achievement, school leadership, and the intensity of industry partnerships.

The Q² values for PjBL and critical thinking were greater than zero, indicating that the structural model had predictive relevance for both endogenous constructs.

Table 8. Effect Sizes

Relationship	f ²	Interpretation
Curriculum adaptability → PjBL	0.748	Large
Curriculum adaptability → Critical thinking skills	0.083	Small
PjBL → Critical thinking skills	0.369	Large

Curriculum adaptability had a large effect size on PjBL, while PjBL had a large effect size on critical thinking. In contrast, the direct effect size of curriculum adaptability on critical thinking was small. This result suggests that curriculum adaptability may be more consequential when it is translated into active classroom practices rather than remaining at the level of curriculum planning or administrative flexibility. The standardized root mean square residual was 0.057, below the commonly used reference value of 0.08. The normed fit index was 0.913. Although model-fit indices in PLS-SEM should be interpreted cautiously, these results indicated that the proposed model did not exhibit a substantial discrepancy between the observed and model-implied correlation structures.

Mediation Analysis

The fourth hypothesis examined whether PjBL mediated the relationship between curriculum adaptability and critical thinking skills. The indirect effect was calculated by multiplying the curriculum adaptability-to-PjBL coefficient by the PjBL-to-critical-thinking coefficient.

Table 9. Direct, Indirect, and Total Effects

Effect	β	Standard Error	t-Statistic	p-Value	95% Confidence Interval	Conclusion
Direct effect: CA → CT	0.247	0.058	4.259	<0.001	[0.137, 0.362]	Significant
Indirect effect: CA → PjBL → CT	0.339	0.044	7.705	<0.001	[0.256, 0.429]	Significant
Total effect: CA → CT	0.586	0.045	13.022	<0.001	[0.494, 0.671]	Significant

The indirect relationship between curriculum adaptability and critical thinking through PjBL was positive and statistically significant ($\beta = 0.339$, $t = 7.705$, $p < 0.001$). The 95% bootstrapped confidence interval ranged from 0.256 to 0.429 and did not include zero. Therefore, H4 was supported.

Both the direct and indirect relationships remained statistically significant, demonstrating complementary partial mediation. The direct and indirect coefficients also had the same positive direction. These findings indicate that curriculum adaptability was associated with critical thinking through two pathways. First, an adaptable curriculum was directly associated with students' opportunities to engage with relevant, updated, and challenging learning content. Second, curriculum adaptability was indirectly associated with critical thinking by supporting the implementation of meaningful project activities.

The variance accounted for was calculated by dividing the indirect effect by the total effect:

$$VAF = 0.339 / 0.586 \times 100 = 57.85\%.$$

This value indicates that approximately 57.85% of the total relationship between curriculum adaptability and critical thinking operated through PjBL. Therefore, project-based learning constituted a substantial pedagogical mechanism connecting curriculum adaptability with students' cognitive development.

Discussion

Curriculum Adaptability and Students' Critical Thinking Skills

The first finding demonstrated that curriculum adaptability had a positive relationship with students' critical thinking skills. An adaptable curriculum gives teachers greater scope to update learning content, select contextually relevant problems, incorporate new technologies, and adjust assessment tasks. These adjustments can expose students to learning situations that require more than the reproduction of fixed procedures.

In vocational education, rigid curricula may become disconnected from changes in technology and workplace practices. When instructional materials are outdated or overly standardized, students may have fewer opportunities to address unfamiliar problems. By contrast, an adaptable curriculum allows teachers to introduce new industrial cases, local business challenges, technological developments, and community problems into classroom activities. These contextual challenges can encourage students to interpret information, recognize relationships, compare alternatives, and justify decisions.

This interpretation is consistent with current international discussions of curriculum flexibility. The OECD describes curriculum adaptability as involving adjustments to diverse educational needs and contexts while emphasizing that flexibility must be supported by teacher capacity, institutional conditions, and clear curriculum goals. Curriculum autonomy alone does not guarantee better learning because its effectiveness depends on how teachers translate flexibility into instructional decisions.

The finding is also relevant to the direction of Indonesia's *Merdeka Belajar* reform. The reform emphasizes foundational competencies, twenty-first-century skills, holistic assessment, teacher autonomy, and greater flexibility in school-level curriculum implementation. The present results suggest that such flexibility can be associated with critical thinking when it is reflected in actual classroom content, learning activities, and assessment practices.

Nevertheless, the direct effect of curriculum adaptability on critical thinking was relatively small. This finding is theoretically important because curriculum adjustment does not automatically create higher-order thinking. A teacher may update teaching materials or use new digital resources while continuing to employ teacher-centred instruction. Similarly, a curriculum may formally contain critical-thinking competencies without giving students sufficient opportunities to investigate, evaluate, and explain. Curriculum adaptability must therefore be converted into cognitively demanding learning experiences.

Curriculum Adaptability and Project-Based Learning

The second finding showed that curriculum adaptability had a strong positive relationship with the implementation of PjBL. This result indicates that project-based instruction is more likely to occur when teachers have sufficient flexibility to modify content, schedules, learning resources, assessment techniques, and expected outputs.

Authentic projects cannot always be implemented through a rigid sequence of textbook topics. Teachers need to identify relevant problems, combine competencies from several learning units, accommodate differences in project duration, and use assessment criteria that evaluate both learning processes and final products. Curriculum adaptability provides the pedagogical space required for such decisions.

This finding is especially relevant to vocational schools because vocational projects must remain connected to changing occupational practices. The OECD notes that future-ready vocational education systems need to respond to structural changes in work and ensure that learners develop competencies relevant to contemporary labour markets. An adaptable curriculum allows schools to revise projects in response to new machinery, software, production processes, service standards, and local employment opportunities.

The strong relationship between curriculum adaptability and PjBL also supports the argument that PjBL should not be treated merely as a classroom technique. Its implementation depends on broader curriculum conditions. Experienced PjBL practitioners emphasize core practices such as designing meaningful projects, facilitating inquiry, supporting student collaboration, managing project processes, and assessing learning throughout the project. These practices require sufficient curriculum flexibility, teacher competence, time, and institutional support.

In the Bandung vocational-school context, curriculum adaptability can enable programmes to connect projects with local manufacturing, technology, tourism, business, and creative-industry activities. For example, information-technology students can develop digital solutions for local enterprises, business students can design marketing projects, and engineering students can investigate production or maintenance problems. Such contextualization makes vocational learning more relevant to students' future professional environments.

Project-Based Learning and Students' Critical Thinking Skills

The third finding revealed that PjBL had a positive and relatively strong relationship with critical thinking. Students who experienced authentic problems, inquiry, collaboration, product development, presentation, and reflection reported better critical-thinking skills.

PjBL can support critical thinking because projects involve a sequence of cognitively demanding activities. Students must understand the problem, identify the information required, select relevant evidence, distribute responsibilities, test possible solutions, respond to feedback, and explain the quality of their final output. These processes differ from conventional assignments in which students reproduce a predetermined answer.

The finding corresponds with meta-analytic evidence showing that PjBL has a positive contribution to academic, affective, and thinking outcomes. A meta-analysis of 66 experimental and quasi-experimental studies found that PjBL significantly improved learning outcomes compared with traditional instructional models, although the magnitude of the results varied according to subject, educational stage, project duration, and group organization. This variation reinforces the importance of implementation quality rather than merely labelling an assignment as a project.

The result is also consistent with theoretical analysis showing that exposure to meaningful problems and collaborative learning can stimulate critical-thinking processes in project- and problem-based environments. Recent empirical work similarly indicates that project-oriented problem-based STEM activities can strengthen students' critical thinking by requiring them to apply scientific and technological knowledge to authentic challenges.

However, the descriptive results showed that reflection and evaluation obtained comparatively lower scores than collaboration and product development. This finding suggests that project implementation in vocational schools may still emphasize task completion and product quality more than the reasoning process. Students may successfully produce an object, service, or presentation without systematically evaluating the evidence supporting their decisions.

Accordingly, teachers should include explicit critical-thinking scaffolds throughout project activities. These can include guiding questions, evidence-evaluation worksheets, alternative-solution matrices, project journals, peer review, and structured reflection. Research on metacognitive scaffolding in project-based instruction indicates that planning, monitoring, reflection, and evaluation can help learners recognize problems and improve their awareness of their thinking processes.

The Mediating Role of Project-Based Learning

The most important finding was that PjBL partially mediated the relationship between curriculum adaptability and students' critical thinking. The indirect effect was larger than the direct effect, and approximately 57.85% of the total relationship operated through project-based learning.

This result supports the proposed theoretical mechanism. Curriculum adaptability creates the conditions for teachers to select current problems, integrate vocational competencies, adjust learning resources, and develop flexible assessments. However, students benefit cognitively only when these curriculum adjustments are experienced through meaningful learning activities. PjBL serves as the mechanism through which curriculum flexibility becomes active inquiry, collaboration, experimentation, and reflection.

The finding explains why curriculum reforms do not always immediately improve higher-order thinking. Changes in curriculum documents, competency statements, or learning modules may produce limited results when classroom instruction remains dominated by lectures and procedural demonstrations. The presence of an adaptable curriculum is therefore a necessary but insufficient condition. It needs to be accompanied by instructional practices that give students responsibility for investigating and solving problems.

The partial nature of the mediation also shows that curriculum adaptability retained an independent relationship with critical thinking. Some curriculum adjustments may directly support critical thinking even without formal PjBL. Examples include case analysis, practical diagnosis, classroom debate, simulation, inquiry-based demonstrations, and evidence-based assessments. Nevertheless, the larger indirect pathway indicates that PjBL is one of the principal mechanisms through which an adaptable vocational curriculum can contribute to critical-

thinking development. The results extend previous research by integrating curriculum-level and instructional-level factors in a single empirical model. Earlier literature has frequently examined PjBL as an independent teaching intervention. The present model demonstrates that its implementation is closely associated with curriculum conditions and that its relationship with student outcomes should not be analyzed separately from teachers' capacity to adapt curriculum content and activities.

Theoretical Implications

This study provides three theoretical contributions. First, it conceptualizes curriculum adaptability as a measurable educational practice rather than merely a policy principle. The construct includes content updating, technological alignment, industry relevance, contextualization, instructional flexibility, and assessment adaptation.

Second, the study demonstrates that curriculum adaptability is associated with students' critical thinking both directly and indirectly. This finding provides a more comprehensive explanation than models that focus exclusively on learning methods. Students' cognitive development is connected to the interaction between curriculum conditions and classroom pedagogy.

Third, the study identifies PjBL as a complementary partial mediator. This finding indicates that PjBL translates curriculum adaptability into authentic cognitive experiences while curriculum adaptability may also support critical thinking through other pedagogical activities. The model therefore contributes to literature on vocational curriculum implementation, project-based pedagogy, and higher-order thinking.

Practical Implications

Vocational school leaders should treat curriculum adaptability as an institutional capability rather than leaving it entirely to individual teachers. Schools need regular mechanisms for reviewing curriculum relevance, integrating technological developments, collecting industry feedback, and revising vocational projects. Curriculum review teams should involve teachers, school leaders, industry practitioners, and, where appropriate, vocational-school graduates.

Teachers should design projects around authentic and sufficiently complex problems. Projects should not be limited to producing tangible outputs but should require students to explain why a solution was selected, what evidence was used, what alternatives were rejected, and how the product could be improved. Assessment rubrics should therefore include problem analysis, evidence quality, reasoning, solution feasibility, collaboration, reflection, and product quality.

Schools should also strengthen teacher professional development in project design, formative assessment, digital technology, and critical-thinking facilitation. Teachers need practical support to transform curriculum competencies into project-driving questions and manageable project stages. Collaborative planning across subjects can help integrate technical, entrepreneurial, communication, and digital competencies in one project.

Industry partnerships should extend beyond student internships. Industry representatives can contribute to identifying authentic problems, reviewing project proposals, providing technical feedback, and evaluating final products. Such involvement can increase the relevance of projects and help teachers keep curriculum content aligned with occupational developments.

Finally, adequate facilities and equitable access to technology remain necessary. Curriculum flexibility and project-based pedagogy may produce unequal learning opportunities when only certain schools or programmes have access to laboratories, software, equipment, internet connectivity, and external mentors. Education authorities should therefore combine curriculum reform with investment in infrastructure and sustained teacher support.

Limitations of the Results

The findings should be interpreted with several limitations. First, the cross-sectional design identifies statistical relationships but does not establish definitive causal effects. Although the proposed directions were theoretically grounded, longitudinal or experimental research would be required to examine changes in critical thinking over time.

Second, the variables were measured using students' self-reported perceptions. The results may therefore be affected by social desirability, response consistency, and common method bias. Future studies should combine student questionnaires with teacher assessments, classroom observations, curriculum-document analysis, and performance-based critical-thinking tests.

Third, the study was conducted in selected vocational schools in Bandung. The findings may not represent all vocational schools in West Java or Indonesia, particularly schools operating in rural areas or with substantially different facilities and industry relationships.

Fourth, the model focused on curriculum adaptability and PjBL and did not incorporate other potentially important variables. Future studies can examine teacher pedagogical competence, digital readiness, school leadership, learning motivation, academic self-efficacy, industry collaboration, and access to vocational facilities as predictors or moderators.

Despite these limitations, the results provide evidence that curriculum adaptability and PjBL are meaningfully associated with students' critical thinking. The findings particularly demonstrate that adaptable curricula are more likely to contribute to cognitive development when curriculum flexibility is translated into authentic, investigative, collaborative, and reflective project experiences.

Conclusion

This study demonstrates that curriculum adaptability is meaningfully associated with students' critical thinking skills in Bandung vocational schools, both directly and indirectly through *Project-Based Learning*. The findings indicate that an adaptable curriculum becomes more educationally effective when its flexibility is translated into authentic projects that require students to investigate problems, evaluate evidence, collaborate, develop solutions, and reflect on their decisions. The mediating role of *Project-Based Learning* confirms that curriculum flexibility alone is insufficient unless it is implemented through cognitively demanding and contextually relevant instructional practices.

The study contributes to vocational education literature by integrating curriculum adaptability, project-based pedagogy, and critical thinking within a single explanatory model. It extends previous research that commonly examines *Project-Based Learning* as an isolated teaching method by showing that its implementation is closely connected to the capacity of schools and teachers to update curriculum content, respond to technological developments, and align learning activities with industry needs. Practically, the findings can be applied by vocational schools to develop industry-relevant projects, strengthen teacher competence in project design, incorporate critical-thinking indicators into assessment rubrics, and expand industry participation in curriculum and learning development.

The findings should be interpreted cautiously because the study employed a cross-sectional design and relied primarily on students' self-reported perceptions. The selected schools in Bandung may also differ from vocational schools in other regions in terms of facilities, teacher competence, student characteristics, and industry collaboration. Consequently, the statistical relationships identified in this study should not be interpreted as definitive causal effects. Further research should employ longitudinal, experimental, or mixed-method designs and incorporate classroom observations, teacher assessments, curriculum-document analysis, and performance-based critical-thinking measures. Future studies may also examine the moderating roles of teacher digital competence, school leadership, learning facilities, student motivation, and school-industry partnerships in strengthening the relationship between curriculum adaptability, project-based learning, and critical thinking.

Acknowledgement

The authors express their sincere appreciation to the principals, teachers, administrative staff, and students of the participating vocational schools in Bandung for their cooperation and valuable contributions during the data-collection process. The authors also acknowledge the assistance of the curriculum and vocational education experts who reviewed the research instrument and provided constructive suggestions for improving its clarity and relevance. Appreciation is extended to colleagues who assisted with questionnaire distribution, data organization, language editing, and manuscript proofreading.

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This section is a statement from the author that this article has a conflict of interest or not.

References

- ‘Abd al-Bāqy, Muhammad Fuād, *Al-Mu’jam al-Mufabbras li al-Fadh al-Qur’ān al-Karīm*, Ed. I; Mesir: Dār al Hadīth, 1996.
- A. Sirry, Mun’im, *Sejarah Fiqh Islam: Sebuah Pengantar*, Ed. II; Surabaya: Risalah Gusti, 1996.
- Abu Zahrah, Muhammad, *Uṣūl al-Fiqh*, Mesir: Dār al-Fikr al-Arabī, 1958.
- Al- Āmidī, Saifuddīn Abī al-Husain Ali bin Abī Ali bin Muhammad, *Al-Iḥkām fī Uṣūl al-Aḥkām*, Juz I, Ed. I; Lebanon: Dar al-Fikr, 1997.
- Devy, Soraya, dan Dwi Mekar Suci. “The Implementation of Verdict Execution on Providing Maḍīyah Maintenance Following Divorce According to Islamic Law (Case Study in Syar’iyyah Court Banda Aceh).” *Samarah: Jurnal Hukum Keluarga dan Hukum Islam* 4, no. 2 (2020).
- Djawas, Mursyid. “Implementasi Pengelolaan Zakat di Aceh.” *Mazāhib* 15, no. 1 (2016).
- Djawas, Mursyid, dan Sri Astuti Abdul Samad. “Conflict, Traditional, and Family Resistance: The pattern of Dispute Resolution in Acehnese Community According to Islamic Law.” *Samarah: Jurnal Hukum Keluarga dan Hukum Islam* 4, no. 1 (2020).
- Hanapi, Agustin, dan Edy Yuhermansyah. “Urgency of Marriage Registration for Women and Child Protection in Gayo Lues District.” *Samarah: Jurnal Hukum Keluarga dan Hukum Islam* 4, no. 2 (2020).
- Hasballah, Khairuddin. “The Milk Al-Yamin Concept as a Validity of Sexual Relationship in a Modern Context: an Analysis of Muhammad Syahrur’s Thoughts.” *Samarah: Jurnal Hukum Keluarga dan Hukum Islam* 4, no. 2 (2020).
- Kasim, Fajri M, dan Abidin Nurdin. “Study of Sociological Law on Conflict Resolution Through Adat in Aceh Community According to Islamic Law.” *Samarah: Jurnal Hukum Keluarga dan Hukum Islam* 4, no. 2 (2020).