



MEDIATING ROLE OF COLLABORATION COMPETENCE IN PROJECT-BASED LEARNING AND PROBLEM SOLVING

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Info Article Received : 08 April 2026 Revised : 05 Mei 2026 Accepted : 10 Juni 2026 Publication : 30 Juni 2026	Abstract: <i>This study aims to examine the effect of project-based learning on the collaboration competence and problem-solving competence of management students, and to test collaboration competence as the mechanism mediating that relationship. The research applies a quantitative explanatory survey of an ex post facto nature. Respondents are active students of the Management Study Program, Universitas Halu Oleo, selected through purposive sampling on the criterion of having completed at least one project-based course. Data were gathered through a closed-ended online questionnaire and analysed using Partial Least Squares Structural Equation Modeling, with the type of mediation classified according to the typology of Zhao, Lynch, and Chen. The results show that project-based learning strengthens both competences, and that collaboration competence in turn strengthens problem-solving competence. The mediation is complementary: most of the effect travels through collaboration, so effectiveness depends on whether project structures create positive interdependence rather than group assignments alone.</i>
Keywords: Project-Based Learning, Collaboration Competence, Problem-Solving Competence, PLS-SEM.	
Kata Kunci: Pembelajaran Berbasis Proyek, Kompetensi Kolaborasi, Kompetensi Pemecahan Masalah.	
Licensed Under a Creative Commons Attribution 4.0 International License 	Abstrak: Penelitian ini bertujuan menguji pengaruh pembelajaran berbasis proyek terhadap kompetensi kolaborasi dan kompetensi pemecahan masalah mahasiswa manajemen, serta menguji kompetensi kolaborasi sebagai mekanisme yang memediasi hubungan tersebut. Penelitian menggunakan pendekatan kuantitatif dengan explanatory survey yang bersifat ex post facto. Responden adalah mahasiswa aktif Program Studi Manajemen, Universitas Halu Oleo, yang dipilih melalui purposive sampling dengan kriteria telah menempuh sekurang-kurangnya satu mata kuliah berbasis proyek. Data dikumpulkan melalui kuesioner tertutup daring dan dianalisis menggunakan Partial Least Squares Structural Equation Modeling, dengan penentuan tipe mediasi mengikuti tipologi Zhao, Lynch, dan Chen. Hasil penelitian menunjukkan bahwa pembelajaran berbasis proyek memperkuat kedua kompetensi tersebut, dan kompetensi kolaborasi selanjutnya memperkuat kompetensi pemecahan masalah. Mediasi bersifat complementary: sebagian besar pengaruh mengalir melalui kolaborasi, sehingga efektivitasnya bergantung pada sejauh mana struktur proyek menciptakan interdependensi positif, bukan sekadar keberadaan tugas kelompok.

INTRODUCTION

The Indonesian labour market displays a structural problem that has not been resolved by the expansion of access to higher education. Statistics Indonesia recorded a national open unemployment rate of 4.68 percent of a labour force of 154.91 million people in February 2026 (Badan Pusat Statistik, 2026). The aggregate figure appears favourable, yet its breakdown by level of education reveals a pattern that warrants attention. The highest unemployment rate is indeed found among graduates of vocational secondary schools at 7.74 percent and general secondary schools at 6.23 percent, while the lowest is found among those who completed primary education or less at 2.32 percent. Nevertheless, graduates of higher education (Diploma IV, bachelor's, master's, and doctoral degrees) recorded an unemployment rate of 6.13 percent, almost equal to that of general secondary school graduates, far above the national rate, and in fact higher than the 4.80 percent recorded by Diploma I/II/III graduates. This last comparison is the most revealing: Diploma I/II/III is a shorter and less costly vocational track, so the additional years of study in the academic track do not yield an absorption advantage commensurate with the time and money invested. The problem therefore lies not in the length of formal education but in the fit between the competences formed by universities and those demanded by employers.

Evidence that the problem is structural rather than a seasonal fluctuation is reinforced by a study of the Institute for Economic and Social Research of the Faculty of Economics and Business, Universitas Indonesia, entitled *Membaca Sinyal Putus Asa di Pasar Kerja Indonesia*. The report notes that the number of people who stopped looking for work out of discouragement rose by 11 percent, from 1.68 million in February 2024 to 1.87 million in February 2025, of whom approximately 45,000 held bachelor's degrees and more than 6,000 held postgraduate degrees. The researchers interpret this finding as a sign that discouragement is not confined to those with low levels of education but may also arise when the promise of upward mobility through higher education fails to materialise (Hanri & Sholihah, 2025). At the local level, the characteristics of the Southeast Sulawesi labour market present a distinctive absorption challenge. Statistics Indonesia for Southeast Sulawesi Province recorded a labour force of 1,457.23 thousand people in February 2026 with an open unemployment rate of 3.25 percent. Although this unemployment figure is relatively low, 875.04 thousand people, or 62.07 percent of those employed, work in the informal sector, with the largest absorption occurring in agriculture, forestry, and fisheries (36.06 percent) (Badan Pusat Statistik Provinsi

Sulawesi Tenggara, 2026). This structure indicates that a low unemployment rate does not automatically reflect the availability of quality formal employment for university graduates, and it simultaneously raises the demand for graduates capable of creating and managing their own enterprises, an ability that rests on problem-solving competence and cooperation.

Meanwhile, the competences demanded by the world of work are shifting in a direction that cannot be met by mastery of disciplinary content alone. The Future of Jobs Report 2025 states that analytical thinking remains the leading core skill sought by employers, considered essential by seven out of ten companies, followed by resilience, flexibility, and agility as well as leadership and social influence, which confirms the importance of adaptability and collaboration alongside cognitive skills. The same report projects that 39 percent of key skills in the labour market will change by 2030 (World Economic Forum, 2025). For management study programs this gap takes a distinctive form. Conceptually, managerial practice is a collective activity of identifying organisational problems, weighing alternatives, and making decisions under uncertainty. To the extent that course design provides no room for students to undergo that process in a genuine setting, learning outcomes stop at knowledge about management without the experience of carrying out the managerial process itself. The question then becomes an empirical one: to what extent does a learning model that places students on real projects actually form both competences, and through which pathway does that effect operate.

Project-Based Learning (PjBL) is a learning model that places complex, authentic, and time-bound projects at the centre of the curriculum rather than as an addition at the end of a course. Such projects require sustained inquiry, student autonomy in decision making, reflection and revision, and result in a publishable product (Thomas, 2000). A recent synthesis of experimental evidence confirms that the benefits of PjBL depend on the rigour with which these elements are implemented rather than on the use of the model's label (De Vivo, 2022). Its epistemological foundation is constructivism, which views knowledge as constructed through the learner's active interaction with real problems, together with experiential learning (Kolb, 1984), which places concrete experience at the starting point of the learning cycle. Problem-solving competence in this study refers to the framework of Polya (1973), namely understanding the problem, devising a plan, carrying out the plan, and looking back at the result, operationalised in the managerial context as problem identification, information analysis, formulation of alternative solutions, decision making, and evaluation of solutions.

To explain the link between collaboration and cognitive attainment, this study draws on social interdependence theory (Johnson & Johnson, 2009). The theory holds that when a task structure creates positive interdependence, that is, when the success of an individual depends on the success of other members, promotive interaction emerges in the form of mutual explanation, challenging one another's reasoning, and negotiating differences of viewpoint. It is this promotive interaction that produces higher cognitive attainment. Its theoretical implication forms the basis of the present research model: collaboration is not positioned as an outcome standing alongside problem solving, but as the mechanism that bridges learning structure and students' cognitive attainment. PjBL provides a task structure that creates positive interdependence; that interdependence builds collaboration competence; and collaboration competence in turn supports students' ability to solve managerial problems.

Empirical evidence on the effectiveness of PjBL is relatively strong and consistent. The meta-analysis of Zhang and Ma (2023) concludes that PjBL has a positive impact on learning outcomes across educational levels, subjects, and student backgrounds. Chen and Yang (2019) revisited the effect of PjBL on academic achievement by investigating moderating variables and found that effect sizes vary according to study and participant characteristics. At the higher education level, the systematic review of Becerra-Goicochea et al. (2026) found that PjBL contributes to the development of soft skills. In the domain of collaboration, Rob (2007) showed that PjBL strengthens team formation in a management information systems curriculum; Pranjol et al. (2024) found that the collaborative creation of learning resources enhances cohort identity and transferable skills; Llorent et al. (2022) demonstrated that cooperative PjBL improves social-emotional competences including collaboration; and Rohmah et al. (2020) showed an increase in learning engagement through group work within PjBL. Apriwijayanti et al. (2025) found that PjBL simultaneously improves problem-solving ability and mutual cooperation. In the domain of problem solving, Wati et al. (2024) and Wang et al. (2025) reported significant improvement through pre- and post-intervention measurement, while Faozi et al. (2020) demonstrated a similar gain through PjBL based on a learning community. Rehman et al. (2023) found that mathematics PjBL fosters twenty-first century skills among primary school students, and Hornejas and Guntalid (2024) reported gains in content mastery and cognitive skills among secondary school biology students. A number of recent studies have begun to address the question of mechanism. Kim and Kim (2021) found that the effectiveness of PjBL in promoting collaborative

problem solving depends on the type of interaction among group members and on the level of learning motivation. Zhang and Hwang (2023) identified an interaction between peer assessment and problem-solving tendency in relation to learning achievement and collaboration. Chen and Jin (2025) traced the mechanisms and pathways linking digital competence with critical thinking in PjBL. On the other hand, Mutanga (2024) documented students' experiences and perceptions of PjBL qualitatively, while in the Indonesian context Yulianti (2024) examined the development of soft skills through PjBL in a character-building course at a university.

Based on the author's search of the Scopus-indexed PjBL literature, three gaps were identified that form the basis of this study. First, the available empirical evidence is concentrated in STEM and school settings, namely physics (Wati et al., 2024; Wang et al., 2025), mathematics (Chhabra & Gawande, 2025; Rohmah et al., 2020; Rehman et al., 2023; Kim & Kim, 2021), biology (Hornejas & Guntalid, 2024), biomedical science (Pranjol et al., 2024), geotechnics (Macedo & Pinho-Lopes, 2015), engineering (Maladzhi et al., 2024), STEM in general (Chandra et al., 2025), and primary education (Llorent et al., 2022). The characteristics of projects in management education differ conceptually: the problems are ill-structured, have no single correct answer, and depend heavily on contextual judgement. Generalising findings from STEM settings therefore requires separate testing.

Second, the connecting mechanism has so far been treated as a moderator rather than as a mediator. Previous research generally treats collaboration and problem solving as two parallel outcomes of PjBL (Trisdiono et al., 2019; Apriwijayanti et al., 2025). Some studies have recognised that the effect of PjBL is not uniform: Chen and Yang (2019) investigated moderators affecting effect size, while Kim and Kim (2021) showed that interaction type and motivation condition collaborative problem-solving attainment. Both, however, position these factors as variables that condition the strength of a relationship rather than as variables that transmit an effect. Social interdependence theory implies the latter, namely that promotive interaction within a team is the pathway through which the effect of learning structure reaches cognitive attainment. To the extent of the author's search, the testing of collaboration as a mediating variable has not been carried out explicitly.

Third, the coverage of disciplinary contexts remains limited. Studies of PjBL in Indonesian higher education have been conducted, for instance by Yulianti (2024) in a character-building course with general soft skills as the outcome. However, to the extent

of the author's search of the Scopus database, no study has tested the model in a management study program with target competences specific to the managerial process. Given the differences in labour market characteristics across regions described earlier, testing in this context carries its own novelty. On this basis, this article aims to examine the effect of students' perceived implementation of Project-Based Learning on collaboration competence and problem-solving competence, and to test the role of collaboration competence as a mediating variable in the relationship between PjBL and problem-solving competence. The scope of the study is limited to active students of the Management Study Program, Faculty of Economics and Business, Universitas Halu Oleo, who have completed at least one project-based course, with measurement carried out at a single point in time.

The theoretical contribution of this study is to extend the application of social interdependence theory to the context of management higher education by positioning collaboration as an explanatory mechanism rather than as a parallel outcome. Its practical contribution is an empirical basis for improving the design of project-based learning within the faculty. Accordingly, this study proposes four hypotheses, namely that PjBL implementation has a positive and significant effect on collaboration competence (H1); collaboration competence has a positive and significant effect on problem-solving competence (H2); PjBL implementation has a positive and significant effect on problem-solving competence (H3); and collaboration competence mediates the effect of PjBL implementation on problem-solving competence (H4).

METHOD

This study employs a quantitative approach with an explanatory survey design of an *ex post facto* nature. The quantitative approach was chosen because the aim of the study is to test hypotheses concerning relationships between variables that have been formulated deductively from theory. The *ex post facto* design was used because the researcher did not administer any treatment or manipulate the independent variable, but instead measured students' perceptions of PjBL implementation in courses that had already taken place. Data collection was cross-sectional, that is, carried out at a single point in time. The methodological consequence of this design is acknowledged explicitly: the findings explain associative and structural relationships between variables rather than causal relationships in the experimental sense. The population of the study comprises all active students of the Management Study Program, Faculty of Economics and Business,

Universitas Halu Oleo. The sampling technique used was purposive sampling, on the consideration that not all members of the population have experience relevant to the variables under study. The inclusion criteria cover three points, namely (1) holding active student status; (2) having completed at least one course requiring the completion of a group project, namely Entrepreneurship, Business Feasibility Study, or Management Information Systems; and (3) willingness to participate voluntarily as a respondent.

The minimum sample size was determined using the inverse square root method (Kock & Hadaya, 2018). This method was chosen because it is designed specifically for PLS-SEM and is based on the smallest path coefficient to be detected rather than on the number of indicators or the number of arrows pointing at a construct, which makes it more consistent with the nature of PLS estimation than either the ten-times rule or power analysis based on multiple regression. Assuming a minimum path coefficient of 0.3, a significance level of 5 percent, and statistical power of 80 percent, a minimum sample size of 69 respondents was obtained, rounded to 70 respondents. The value of 0.3 was chosen as the lower bound because the review of previous research presented in the introduction consistently reports effects of PjBL on collaboration and on problem solving at moderate to strong levels, so that coefficients below that value were judged to be of limited practical significance. The data collection target was set at 90 to 100 respondents in order to provide a margin against incomplete questionnaires and careless responses, and at the same time to maintain the stability of estimates in testing indirect effects, which generally requires greater statistical power than the testing of direct effects. The consequence of this choice is acknowledged openly: with a sample of this size, path coefficients smaller than 0.3 may fail to be detected as significant, so the interpretation of results is focused on effects of moderate size and above.

RESULTS AND DISCUSSION

Respondent Characteristics

The questionnaire was distributed to active students of the Management Study Program, Faculty of Economics and Business, Universitas Halu Oleo who met the inclusion criteria. Of the 112 responses received, 95 were found to be complete and suitable for analysis after screening for unanswered items, respondents who had not taken a project-based course, and careless response patterns. This number exceeds the minimum sample size of 70 respondents and falls within the target range of 90 to 100 respondents. An overview of respondent characteristics is presented in Table 1. Most

respondents belong to the 2023 cohort (50.5 percent), the largest group had completed two project-based courses (41.1 percent), and Entrepreneurship was the course most frequently cited as the project experience being assessed (37.9 percent). Percentages in Table 1 may not total exactly 100.0 because of rounding.

Table 1. Respondent Characteristics (n = 95)

Characteristic	Category	Frequency	Percentage(%)
Gender	Male	38	40
	Female	57	60
Cohort	2022	34	35.8
	2023	48	50.5
	Others	13	13.7
Number of project-based courses completed	1 course	32	33.7
	2 courses	39	41.1
	≥ 3 courses	24	25.3
Project course referred to	Entrepreneurship	36	37.9
	Business Feasibility Study	31	32.6
	Management Information Systems	28	29.5

Source: Processed data, 2026.

Measurement Model Evaluation (Outer Model)

The measurement model was evaluated using SmartPLS 4 and covers convergent validity, reliability, and discriminant validity. Convergent validity at the indicator level was assessed first through outer loading values. As presented in Table 2, 34 of the 36 indicators have outer loadings above the 0.70 threshold, ranging from 0.707 to 0.883. Two indicators of the PjBL implementation construct, namely X3 (0.662) and X11 (0.660), fall slightly below the threshold. Both were retained because they remain within the range of 0.40 to 0.70 and their removal would not meaningfully increase the AVE or the composite reliability of their construct, while the content of both items is still needed to preserve conceptual coverage of the dimensions of task authenticity and reflection (Hair et al., 2022).

Table 2. Outer Loading Values

Construct	Indicator	Outer loading	Remark
PjBL Implementation (X)	X1	0.841	Valid
	X2	0.785	Valid
	X3	0.662	Retained
	X4	0.859	Valid
	X5	0.707	Valid
	X6	0.841	Valid
	X7	0.792	Valid
	X8	0.796	Valid
	X9	0.728	Valid
	X10	0.879	Valid

	X11	0.66	Retained
	X12	0.75	Valid
Collaboration Competence (M)	M1	0.829	Valid
	M2	0.818	Valid
	M3	0.806	Valid
	M4	0.803	Valid
	M5	0.833	Valid
	M6	0.839	Valid
	M7	0.809	Valid
	M8	0.821	Valid
	M9	0.768	Valid
	M10	0.883	Valid
	M11	0.762	Valid
	M12	0.853	Valid
Problem-Solving Competence (Y)	Y1	0.824	Valid
	Y2	0.793	Valid
	Y3	0.839	Valid
	Y4	0.877	Valid
	Y5	0.81	Valid
	Y6	0.842	Valid
	Y7	0.769	Valid
	Y8	0.79	Valid
	Y9	0.776	Valid
	Y10	0.881	Valid
	Y11	0.723	Valid
	Y12	0.816	Valid

Source: Processed data, 2026.

Reliability and convergent validity were then examined at the construct level. As presented in Table 3, all constructs have Cronbach's Alpha, rho_a, and composite reliability (rho_c) values above 0.90 and AVE values above 0.60. Internal consistency and convergent validity are therefore well satisfied (Hair et al., 2022). AVE values ranging from 0.606 to 0.671 indicate that each construct explains more than 60 percent of the variance of its indicators.

Table 3. Construct Reliability and Average Variance Extracted

Construct	Cronbach's α	rho a	rho c	AVE	Remark
PjBL Implementation (X)	0.94	0.943	0.948	0.606	Reliable
Collaboration Competence (M)	0.955	0.958	0.961	0.671	Reliable
Problem-Solving Competence (Y)	0.953	0.956	0.959	0.661	Reliable

Source: Processed data, 2026.

The internal consistency values of the collaboration competence construct ($\alpha = 0.955$; rho_c = 0.961) and the problem-solving competence construct ($\alpha = 0.953$; rho_c = 0.959) exceed 0.95. Hair et al. (2022) regard values above that threshold not merely as

a sign of high measurement quality but also as a possible indication of item redundancy or uniform response patterns. Two considerations suggest that this risk is under control. First, the AVE values of the three constructs lie between 0.606 and 0.671, far from values that would signal indicators duplicating one another's content. Second, all HTMT values remain below the 0.90 threshold, so the constructs remain empirically distinguishable. Nevertheless, the use of twelve items per construct mechanically raises reliability, so the development of a more parsimonious instrument deserves consideration in future research.

Discriminant validity was assessed using the heterotrait-monotrait ratio (HTMT) with a maximum threshold of 0.90. As presented in Table 4, all HTMT values between constructs fall below that threshold, ranging from 0.670 to 0.818. The highest value is found for the pair of collaboration competence and problem-solving competence (0.818), which still meets the criterion although it approaches the threshold, consistent with their theoretical position as closely related constructs. The three constructs are therefore empirically distinct and the measurement model is suitable for progression to structural model evaluation (Henseler et al., 2015).

Table 4. Discriminant Validity-Heterotrait-Monotrait Ratio (HTMT)

Construct	X	M	Y
X (PjBL Implementation)	—		
M (Collaboration Competence)	0.674	—	
Y (Problem-Solving Competence)	0.67	0.818	—

Source: Processed data, 2026.

Collinearity and Common Method Bias Testing

Before interpreting the path coefficients, collinearity among predictor constructs was examined through inner VIF values with a threshold below 5 (Hair et al., 2022). The same values also served for the full collinearity assessment as a statistical test of common method bias, using the stricter criterion that all VIF values remain below 3.3 (Kock, 2015). As presented in Table 5, all inner VIF values lie between 1.000 and 1.710 and all full collinearity VIF values lie between 1.865 and 2.860, so both criteria are met. Harman's single-factor test produced a single factor explaining 51.36 percent of the variance, slightly above the 50 percent threshold. This figure is not interpreted as evidence of serious common method bias, given that Harman's test has long been criticised for its low sensitivity and its tendency to yield high values in models whose constructs are theoretically strongly correlated (Podsakoff et al., 2003). The more

diagnostic criterion, namely the full collinearity assessment with a threshold of 3.3 (Kock, 2015), is fully satisfied, and procedural controls were applied from the instrument development stage onwards.

Table 5. Collinearity Test (VIF) and Full Collinearity Assessment

Path / Construct	Inner VIF	Full collinearity VIF	Remark
$X \rightarrow M$	1	1.865	Satisfied
$X \rightarrow Y$	1.71	2.86	Satisfied
$M \rightarrow Y$	1.71	2.849	Satisfied

Source: Processed data, 2026. Note: the full collinearity VIF values in the rows $X \rightarrow M$, $X \rightarrow Y$, and $M \rightarrow Y$ are the values for constructs X , M , and Y respectively.

Structural Model Evaluation (Inner Model)

Structural model evaluation begins with the coefficient of determination (R^2) and predictive relevance (Q^2) obtained through the blindfolding procedure with an omission distance of seven. As presented in Table 6, PjBL implementation explains 41.5 percent of the variance in collaboration competence, while PjBL implementation together with collaboration competence explains 64.9 percent of the variance in problem-solving competence. Both Q^2 values are greater than zero, namely 0.293 and 0.439, indicating that the model has predictive relevance for both endogenous constructs.

Table 6. R-square and Q-square Values

Endogenous construct	R^2	Category	Q^2	Remark
Collaboration Competence (M)	0.415	Weak–moderate	0.293	Relevant
Problem-Solving Competence (Y)	0.649	Moderate	0.439	Relevant

Source: Processed data, 2026.

Effect size (f^2) was computed to assess the contribution of each predictor construct to its endogenous construct, using the categories small (0.02), medium (0.15), and large (0.35). As presented in Table 7, the effect of PjBL implementation on collaboration competence is large ($f^2 = 0.710$), the effect of collaboration competence on problem-solving competence is likewise large ($f^2 = 0.672$), whereas the direct effect of PjBL implementation on problem-solving competence is small ($f^2 = 0.091$). This pattern provides an initial indication that the contribution of PjBL to problem-solving competence operates more through the formation of collaboration competence than directly.

Table 7. Effect Size (f-square)

Path	f^2	Category
$X \rightarrow M$	0.71	Large
$X \rightarrow Y$	0.091	Small
$M \rightarrow Y$	0.672	Large

Source: Processed data, 2026.

Hypothesis Testing

The significance of path coefficients was tested using the bootstrapping procedure with 5,000 subsamples. A hypothesis is accepted when the sign of the coefficient matches the hypothesised direction and the t-statistic exceeds 1.96 with p below 0.05. A summary of the tests of the three direct effects (H1, H2, and H3) together with the indirect effect through collaboration competence (H4) is presented in Table 8. All four hypotheses proposed are supported by the data.

Table 8. Hypothesis Testing Results-Path Coefficients and Indirect Effect

Hyp.	Path	β (O)	STDEV	t	p	Decision
H1	$X \rightarrow M$	0.644	0.071	9.105	< 0.001	Accepted
H2	$M \rightarrow Y$	0.635	0.061	10.493	< 0.001	Accepted
H3	$X \rightarrow Y$ (direct)	0.233	0.074	3.166	0.002	Accepted
H4	$X \rightarrow M \rightarrow Y$ (indirect)	0.409	0.064	6.411	< 0.001	Accepted
—	$X \rightarrow Y$ (total)	0.643	0.066	9.739	< 0.001	—

Source: Processed data, 2026.

The type of mediation was determined following the typology of Zhao, Lynch, and Chen (2010), which bases its classification on two considerations, namely the significance of the indirect effect and the status of the direct effect once the mediator is included in the model. The results in Table 8 show that the indirect effect is significant ($\beta = 0.409$; $t = 6.411$; $p < 0.001$) and that the direct effect also remains significant with the same sign ($\beta = 0.233$; $t = 3.166$; $p = 0.002$). The role of collaboration competence is therefore classified as complementary mediation, that is, partial mediation running in the same direction as the direct effect. The proportion of the total effect transmitted through the mediator, expressed as the variance accounted for (VAF), is 63.7 percent. This value is computed from the ratio of the indirect effect to the sum of the direct and indirect effects; the difference of 0.001 relative to the total effect reported in Table 8 is due to rounding. The figure means that almost two-thirds of the effect of PjBL implementation on problem-solving competence operates through the formation of collaboration competence.

Discussion

The first hypothesis is supported: PjBL implementation has a positive and significant effect on collaboration competence, with the largest path coefficient in the model ($\beta = 0.644$) and an effect size classified as large ($f^2 = 0.710$). This finding is consistent with social interdependence theory (Johnson & Johnson, 2009), which holds that a task structure with positive interdependence gives rise to promotive interaction

among group members. Group projects in the courses Entrepreneurship, Business Feasibility Study, and Management Information Systems require students to divide roles, negotiate differences of viewpoint, and bear the outcome of their work jointly, so that collaboration competence is formed as a direct consequence of that task structure. This result is consistent with Rob (2007), Llorent et al. (2022), Pranjol et al. (2024), and Apriwijayanti et al. (2025), who found that cooperation is strengthened through project-based learning.

Theoretically, the magnitude of the coefficient on this path can be explained through the causal chain postulated by social interdependence theory. Johnson and Johnson (2009) distinguish three elements that operate in sequence, namely a structure of interdependent goals, the promotive interaction that arises from that structure, and the learning outcomes produced by that interaction. The first element is structural and inheres in task design, so its relationship with the formation of collaboration competence is the most proximal of the three. The characteristics of PjBL as formulated by Thomas (2000), namely a driving question that cannot be answered by one person alone, group autonomy in determining the approach to a solution, and a final product assessed as a single whole, essentially constitute the operationalisation of that structure of interdependent goals. The largest path coefficient, on the relationship $X \rightarrow M$, is therefore not an isolated finding but a logical consequence of the conceptual proximity between project task structure and the conditions the theory requires for promotive interaction to emerge.

The second hypothesis is likewise supported: collaboration competence has a positive and significant effect on problem-solving competence with an effect size that is also large ($\beta = 0.635$; $f^2 = 0.672$). This finding confirms the core proposition of social interdependence theory that promotive interaction within a team, in the form of mutual explanation and challenging one another's reasoning, produces higher cognitive attainment. In the context of management education, the problems students face are ill-structured and have no single answer, so the ability to gather differing viewpoints and test them collectively becomes part of the problem-solving process itself. This result is in line with Trisdiono et al. (2019) and Zhang and Hwang (2023).

The theoretical explanation of this path becomes sharper when the propositions of social interdependence theory are brought together with Polya's (1973) problem-solving framework. Polya's four stages call for cognitive operations that are precisely those strengthened by promotive interaction. At the stage of understanding the problem, the exchange of interpretations among members helps students recognise that a single

formulation of a managerial problem can be read from several viewpoints. At the stage of devising a plan, the obligation to explain the reasons for a choice to peers forces reasoning that was initially implicit to become explicit and therefore open to scrutiny. At the stage of carrying out the plan, the division of roles allows several alternatives to be tested in parallel within the same span of time. At the stage of looking back, peer feedback serves as a correction to the limitations of one's own judgement. Promotive interaction is thus not merely a supportive social climate but a cognitive instrument that executes the stages of problem solving themselves. This explains why the effect size of the path $M \rightarrow Y$ is large even though the two constructs originate from different conceptual domains.

The third hypothesis is supported, albeit with the smallest coefficient and effect size among the three direct paths ($\beta = 0.233$; $f^2 = 0.091$). PjBL implementation still contributes directly to problem-solving competence through elements that are not collaborative in nature, such as sustained inquiry, autonomy in determining the approach to a solution, and cycles of reflection and revision (Thomas, 2000; De Vivo, 2022). This finding is consistent with Wati et al. (2024), Wang et al. (2025), Faozi et al. (2020), and the meta-analysis of Zhang and Ma (2023), while extending that evidence from STEM settings to management education.

This direct path is best explained through experiential learning (Kolb, 1984) and the constructivist foundation underlying it. Kolb's learning cycle places concrete experience as the starting point, which is then processed through reflective observation, abstract conceptualisation, and active experimentation. Working on a project supplies all four moments without necessarily involving group interaction: students confront a field problem directly, review the steps they have taken, draw generalisable principles, and then test them at the next stage of the project. The small coefficient on this path therefore does not indicate that the individual experiential mechanism is inoperative, but rather that in a project designed to be carried out in groups most of that experience has already been channelled through joint activity. This finding also accords with De Vivo's (2022) insistence that the benefits of PjBL depend on the rigour with which its elements are implemented, since if the elements of inquiry and reflection are applied loosely, it is this direct path that will weaken first, ahead of the collaborative path that remains supported by the structure of group assessment.

The fourth hypothesis, which constitutes the core novelty of this study, is also supported. The indirect effect of PjBL implementation on problem-solving competence

through collaboration competence is significant ($\beta = 0.409$) and indeed larger than its direct effect ($\beta = 0.233$), with both significant and running in the same direction, so that the mediation is classified as complementary. The VAF of 63.7 percent shows that almost two-thirds of the total effect is transmitted through the collaboration mechanism. This finding addresses the second gap identified in the introduction: collaboration is not merely a parallel outcome standing alongside problem solving, as it has been treated in most previous research, but the pathway along which the effect of learning structure travels towards cognitive attainment. In other words, the question of through which pathway PjBL operates receives an empirical answer: largely through the formation of the ability to work together, and to a smaller extent through the experience of independent inquiry.

Viewed theoretically, the classification of complementary mediation carries a more specific meaning than the mere statement that mediation is partial. The significance of both paths in the same direction indicates that two theoretical mechanisms operate side by side rather than cancelling one another out, namely the social mechanism explained by social interdependence theory and the individual experiential mechanism explained by experiential learning. The proportion of 63.7 percent indicates their relative weight, namely that in the context of management education the social mechanism is the more dominant. That dominance can be understood from the ill-structured nature of managerial problems, which have no single criterion of resolution and therefore demand the consideration of many viewpoints before a decision is taken. For problems with a more closed structure, as are frequently encountered in STEM settings, that proportion need not be the same. It is this difference in the character of problems that makes testing the mediation model in the management domain theoretically meaningful rather than a mere replication in a different population.

Theoretically, this study extends the application of social interdependence theory to the context of management higher education by positioning collaboration as an explanatory mechanism. Practically, the findings offer direction for instructional design within the faculty: the effectiveness of PjBL is determined not simply by the presence of a project but by the extent to which the project structure genuinely creates positive interdependence. Group assignments that can be completed through a separated division of labour without mutual dependence risk forfeiting almost two-thirds of their potential effect on problem-solving competence. The formulation of complementary roles, assessment that incorporates a component of individual contribution within the team, and

scheduled space for group reflection therefore deserve consideration as part of the design of project-based courses.

The theoretical contribution of this study accordingly lies in bringing together three frameworks that have largely been used separately in research on PjBL. Thomas (2000) and De Vivo (2022) specify the conditions that make an assignment qualify as project-based learning; Kolb (1984) explains how experience is processed into knowledge; and Johnson and Johnson (2009) explain why particular social structures produce higher cognitive attainment. The mediation model tested here arranges all three into a single sequence that can be examined empirically: the structural characteristics of a project create conditions of positive interdependence, those conditions form collaboration competence, and it is collaboration competence that supports the stages of problem solving as formulated by Polya (1973). The question of the effectiveness of PjBL therefore shifts from whether the model has an effect to the question of through which mechanism that effect operates and under what conditions that mechanism is active.

This study has a number of limitations that should be considered in interpreting its results. The cross-sectional design limits causal inference; all variables were measured through self-perception and may therefore carry method bias, although statistical testing indicates that the risk is under control; coverage of a single study program limits generalisation; and problem-solving competence was measured through perceived ability rather than through actual performance assessment on managerial cases. The R^2 of problem-solving competence of 0.649 also indicates that around one-third of the variance is still explained by factors outside the model. In addition, the sample of 95 respondents does meet the minimum threshold computed in the method section, but it limits the model's ability to detect small path coefficients, so these results should be read as evidence concerning effects of moderate size and above. Future research is advised to adopt a longitudinal design, to widen coverage to other study programs and universities, to add performance-based measurement, and to consider further variables such as learning motivation, lecturer support, or classroom climate as additional mediators or moderators.

CONCLUSION

This study examined the role of collaboration competence as the mechanism transmitting the effect of project-based learning implementation on problem-solving competence among students of the Management Study Program, Faculty of Economics

and Business, Universitas Halu Oleo. All four hypotheses proposed are supported by the data. PjBL implementation has a positive and significant effect on collaboration competence ($\beta = 0.644$) and on problem-solving competence ($\beta = 0.233$); collaboration competence has a positive and significant effect on problem-solving competence ($\beta = 0.635$); and the indirect effect of PjBL implementation on problem-solving competence through collaboration competence is significant ($\beta = 0.409$). Because the direct and indirect effects are both significant and run in the same direction, the role of collaboration competence is classified as complementary mediation with a VAF of 63.7 percent.

The principal conclusion is that collaboration is not a by-product standing alongside problem solving, but the main pathway along which the effect of project-based learning structure travels towards students' cognitive attainment. Almost two-thirds of the effect of PjBL implementation on problem-solving competence operates through the formation of the ability to work together, while the remainder operates through experiences of inquiry and autonomy that are not collaborative in nature. This finding extends the application of social interdependence theory to the context of management higher education by positioning collaboration as an explanatory mechanism rather than as a parallel outcome.

The practical implication is that the effectiveness of project-based learning is determined not by the presence of a group assignment but by the extent to which the task structure creates positive interdependence. Assignments that can be completed through a separated division of labour without mutual dependence risk forfeiting most of their potential effect on problem-solving competence. The formulation of complementary roles, assessment incorporating a component of individual contribution within the team, and scheduled space for group reflection therefore need to become an explicit part of the design of project-based courses within the faculty. Taking into account the limitations of the cross-sectional design, the coverage of a single study program, and the reliance on self-perception measures, future research is advised to adopt a longitudinal design, to extend coverage across study programs and universities, and to add measurement of actual performance on managerial cases.

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