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## The Impact of Collaborative Learning Models on University Students' Problem-Solving Abilities

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### ABSTRACT

Problem-solving ability is recognized as one of the essential competencies required in the 21st century, demanding systematic cultivation within higher education. However, conventional teaching approaches still prevalent in many university settings often fall short in fostering this critical skill effectively. This study investigates the impact of a collaborative learning model on students' problem-solving capabilities. Employing a quasi-experimental design with a pretest-posttest control group format, the study involved two student groups: an experimental group exposed to collaborative learning strategies and a control group receiving traditional instruction. Data were analyzed using independent t-tests, multiple linear regression, and classical assumption testing. The findings reveal a statistically significant difference in posttest mean scores between the two groups ( $p < 0.001$ ), with the experimental group demonstrating a notably greater improvement. The intervention variable (learning model) showed a strong influence on learning outcomes, while students' initial abilities (pretest scores) were not a significant predictor of posttest performance. These results suggest that collaborative learning effectively enhances students' problem-solving skills, primarily through social interaction and collective reflection. The study's findings align with Vygotsky's sociocultural theory and are supported by contemporary research on active learning and adaptive expertise. Based on these insights, the study advocates for the broader implementation of collaborative learning models as a pedagogical strategy in higher education to address the evolving demands of 21st-century education.

## INTRODUCTION

Despite the growing body of literature on collaborative learning, significant research gaps remain. Many prior studies relied on descriptive or pre-experimental designs, limiting causal inference about its actual impact on problem-solving abilities. Furthermore, assessment tools often focused on multiple-choice or recall-based tasks, which do not authentically capture the complexity of students' problem-solving processes. In the Indonesian higher education context, systematic studies employing rigorous quasi-experimental designs remain scarce. This study seeks to fill these gaps by applying a contextualized collaborative learning model and assessing its impact on problem-solving skills using validated, authentic instruments based on Polya's framework. The demands of 21st-century education have undergone a fundamental shift—from passive, teacher-centered instruction to active, participatory, and collaboration-based learning. In this evolving landscape, university students are expected not only to grasp theoretical knowledge but also to apply it effectively in dynamic and problem-laden contexts. Within this framework, problem-solving ability emerges as a core competency and a hallmark of higher-order thinking skills. This ability is essential not only in academic settings but also in professional and societal spheres, where adaptability and critical decision-making are increasingly valued.

Recent meta-analytic studies have highlighted the significant positive impact of collaborative learning approaches on the development of students' critical thinking skills (Xu & Wang, 2023). In particular, the collaborative problem-solving model has been shown to enhance cognitive interaction and deepen conceptual understanding. These improvements, in turn, contribute to sharper analytical reasoning and more effective problem resolutions, especially when students are faced with complex, real-world challenges (Kurniawati et al., 2024).

Indonesian higher education is also undergoing a paradigm shift, driven by the implementation of the Merdeka Belajar–Kampus Merdeka (MBKM) policy, which grants greater autonomy for

institutions and students to design contextualized and flexible learning experiences. Under this policy framework, problem-based and project-based learning have been promoted as key strategies to cultivate graduates who are both adaptive and competent in facing real-world challenges. Nevertheless, a significant barrier remains: the persistence of conventional, teacher-centered approaches that often limit interaction and suppress intellectual engagement. Such approaches provide limited opportunities for students to develop critical thinking and deep problem-solving abilities (Sucipto et al., 2024). This underscores the urgent need for strategic pedagogical interventions—particularly through learning models that actively stimulate intellectual engagement, foster meaningful participation, and encourage collective reflection in tackling authentic problems.

Theoretically, collaborative learning is deeply rooted in the sociocultural constructivist theory proposed by Lev Vygotsky, particularly through the concept of the Zone of Proximal Development (ZPD). ZPD refers to the gap between what learners can achieve independently and what they can accomplish with the guidance of more capable individuals, including peers (Vygotsky, 1978). In this framework, collaborative learning emphasizes social interaction as the central medium through which knowledge is internalized, allowing students to both offer and receive scaffolding that accelerates their cognitive development (Khosravizadeh, 2023).

Collaborative learning is firmly rooted in Vygotsky's sociocultural constructivism, particularly the Zone of Proximal Development (ZPD), which emphasizes the role of social interaction and scaffolding in accelerating learners' cognitive development. Within collaborative settings, students benefit from peer dialogue, negotiation of meaning, and shared responsibility, which collectively strengthen higher-order thinking. Beyond ZPD, the concept of adaptive expertise also provides a strong theoretical lens, suggesting that collaboration fosters not only efficiency but also flexibility, creativity, and innovative problem-solving approaches (Hatano & Inagaki, 2023).

Empirical studies further validate these theoretical perspectives. A comprehensive meta-analysis by Chen et al. (2023) confirmed that collaborative strategies consistently improve problem-solving, communication, and critical thinking across higher education disciplines. Lopez & Hernandez (2024) demonstrated that when collaborative learning is combined with authentic assessment, students exhibit stronger knowledge transfer and longer-term retention of complex concepts. Similarly, Park & Kim (2024) reported that authentic, group-based assessment tasks deepen reflective judgment and adaptive problem-solving, highlighting the central role of authentic assessment in collaborative learning environments.

Empirical evidence supports this theoretical foundation: structured interactions within small groups have been shown to significantly enhance the quality of student argumentation, communication skills, and problem-solving abilities, particularly in active learning environments (Tan et al., 2024). These findings highlight the cognitive and social advantages of collaboration in higher education settings, especially when designed intentionally to support deep engagement and mutual learning.

Beyond Vygotsky's theoretical framework, the concept of Adaptive Expertise is also highly relevant in understanding how collaborative learning fosters cognitive flexibility among university students. In this context, learners are expected not only to arrive at correct solutions but also to explore multiple alternative approaches that may prove more efficient or innovative. Collaborative processes provide a platform for critical dialogue, diverse perspectives, and collective reflection, all of which contribute cumulatively to the development of adaptive thinking patterns (Pickal & Ahmad, 2024).

This view is further supported by recent research indicating that the quality of engagement within groups is a stronger predictor of problem-solving success than collaboration per se. In other words, it is not merely the act of working together, but the depth and intentionality of collaborative engagement that drives meaningful learning outcomes (Zhou & Chan, 2023).

Social interaction within collaborative groups functions not only as a medium for information exchange but also as a critical foundation for emotional and affective dimensions of learning. (Xu & Wang, 2023) emphasize that positive interpersonal relationships within learning groups directly contribute to enhanced academic resilience, learning satisfaction, and students' problem-solving capacity. This aligns with the theory of Positive Interdependence, which posits that the success of one group member is inherently linked to the success of others. As a result, academic solidarity emerges, fostering a supportive learning environment that enhances overall group effectiveness and deepens cognitive engagement (Johnson, 2024).

Although numerous studies have highlighted the benefits of collaborative learning on academic outcomes, limitations remain in terms of research design and contextual application. Several earlier investigations relied primarily on observational or pre-experimental designs, which do not permit causal inferences regarding the impact of collaborative learning on students' problem-solving abilities (Ramos & Yilmaz, 2023). Moreover, there is a notable lack of systematic research in the Indonesian context that rigorously evaluates the effectiveness of collaborative learning using robust quantitative methodologies—particularly studies employing quasi-experimental designs with valid control groups and inferential statistical analysis. This methodological gap underscores the need for more empirical investigations that can establish stronger evidence of effectiveness and inform pedagogical practices more reliably.

Another notable limitation in several previous studies lies in the use of insufficiently authentic assessment instruments for measuring problem-solving ability. Many investigations have relied predominantly on multiple-choice tests or basic written assignments, which fail to capture the complexity of students' cognitive processes in real-world contexts. In the context of collaborative learning, problem-solving skills should ideally be assessed through problem-based activities that require teamwork, argumentative discussion, and

data-driven decision-making. Such authentic assessments better reflect the multifaceted nature of problem solving and align more closely with the interactive and reflective demands of collaborative learning environments.

Despite the growing body of literature on collaborative learning, significant research gaps remain. Many prior studies relied on descriptive or pre-experimental designs, limiting causal inference about its actual impact on problem-solving abilities. Furthermore, assessment tools often focused on multiple-choice or recall-based tasks, which do not authentically capture the complexity of students' problem-solving processes. In the Indonesian higher education context, systematic studies employing rigorous quasi-experimental designs remain scarce. This study seeks to fill these gaps by applying a contextualized collaborative learning model and assessing its impact on problem-solving skills using validated, authentic instruments based on Polya's framework.

Given the aforementioned issues, there is a pressing need for research that specifically examines the impact of collaborative learning models on university students' problem-solving abilities. This study aims to address the existing knowledge gap, particularly regarding the implementation of collaborative learning in Indonesian higher education and the extent to which such models contribute to the development of critical thinking and problem-solving skills. More specifically, this study aims to analyze and examine the significant impact of implementing collaborative learning on university students' problem-solving abilities, as compared to conventional instructional approaches. Through this research, it is expected that empirical evidence will be generated to support the development of more innovative and student-centered learning strategies, tailored to meet the evolving challenges of higher education in the 21st century.

The findings of this study are expected to provide higher education institutions with new insights for designing and implementing more effective learning approaches that align with the demands of 21st-century education. Furthermore, the

results are anticipated to contribute to the development of higher education policies that holistically strengthen essential student competencies not only in cognitive domains, but also in social and collaborative dimensions.

## **METHODS**

The assessment instrument was structured around Polya's (1973) four classic indicators of problem-solving: (1) Understanding the problem—representing comprehension and analytical ability; (2) Devising a plan—reflecting strategic thinking and creativity; (3) Implementing the strategy—capturing procedural fluency and logical reasoning; and (4) Evaluating the solution—indicating reflective judgment and critical evaluation. These dimensions directly align with the higher-order learning objectives of the course, which emphasize analytical reasoning, collaborative inquiry, and reflective problem-solving. Furthermore, the indicators were mapped to the stages of the collaborative learning model (problem identification, group discussion, presentation, and reflection), ensuring coherence between learning objectives, instructional design, and assessment.

This study was conducted during the even semester of the 2023/2024 academic year, specifically from January to June 2025. The research involved six face-to-face sessions, during which learning activities and data collection were carried out directly in the classroom setting. The study was implemented within the undergraduate program of Family Welfare Education, Faculty of Engineering, Universitas Negeri Makassar.

This study employed a quantitative approach using a quasi-experimental design, specifically the pretest-posttest control group design. This design was chosen because it offers adequate control over external variables and allows for the direct measurement of treatment effects (Creswell, 2012). In this framework, two groups were established: an experimental group, which received instruction through the collaborative learning model, and a control group, which was taught using conventional lecture-based methods.

The population of this study consisted of all third-semester students enrolled in the undergraduate Family Welfare Education program. The sampling technique used was purposive sampling, based on considerations of academic background similarity and prior learning experiences among participants. The total sample comprised 60 students, with 30 assigned to the experimental group and 30 to the control group. Group assignment was randomized based on parallel class divisions. The experimental group received treatment through a collaborative learning model over six sessions (each lasting two hours). The instructional model followed a structured syntax that included: formation of heterogeneous groups, problem identification, group discussion, presentation of results, and reflection. Each session was designed around authentic, real-world problem scenarios to encourage engagement and critical inquiry. The control group, by contrast, received the same instructional content through conventional face-to-face lectures without group interaction or collaborative activities.

The primary instrument used to assess students' problem-solving abilities was a contextual essay-based test, developed in reference to the problem-solving indicators proposed by Polya (1973). These indicators include: (1) understanding the problem, (2) devising a plan, (3) implementing the strategy, and (4) evaluating the solution. Content validity was established through expert judgment by three specialists in the field of education. The reliability of the instrument was tested using Cronbach's Alpha, yielding a coefficient score of 0.87, which indicates a high level of internal consistency.

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analytical reasoning, collaborative inquiry, and reflective problem-solving. Furthermore, the indicators were mapped to the stages of the collaborative learning model (problem identification, group discussion, presentation, and reflection), ensuring coherence between learning objectives, instructional design, and assessment.

Before hypothesis testing, the data were examined for normality and homogeneity of variance. Normality was tested using the Shapiro-Wilk test, while homogeneity was assessed using Levene's Test. The primary data analysis employed the independent samples t-test to compare post-test scores between the experimental and control groups. In addition, paired samples t-tests were used to measure the improvement in problem-solving scores within each group by comparing pretest and post-test results. All statistical analyses were conducted using SPSS version 25, with a significance level set at 0.05.

## **RESULTS AND DISCUSSION**

This study makes a novel contribution by addressing both methodological and assessment gaps identified in prior research. Unlike earlier studies relying on less authentic measures, the present research employed Polya's problem-solving framework, ensuring that the instrument captured not only recall but also analytical, strategic, and evaluative competencies. Combined with the quasi-experimental design, this strengthens the validity of the findings and provides a more comprehensive understanding of how collaborative learning enhances students' problem-solving skills.

These conclusions are consistent with recent meta-analytical and empirical research that emphasizes both the cognitive and social gains of collaborative learning (Chen et al., 2023; Lopez & Hernandez, 2024; Park & Kim, 2024). The integration of authentic assessment strategies further underscores the reliability and relevance of this study, aligning with international evidence that such designs capture deeper and more transferable learning outcomes.

This study aimed to examine the effect of a collaborative learning model on university students'

problem-solving abilities. Data were collected through pretests and posttests administered to two groups: an experimental group that received collaborative learning, and a control group that

underwent conventional instruction. The following presents the key findings of this research.

### Classical Assumption Testing

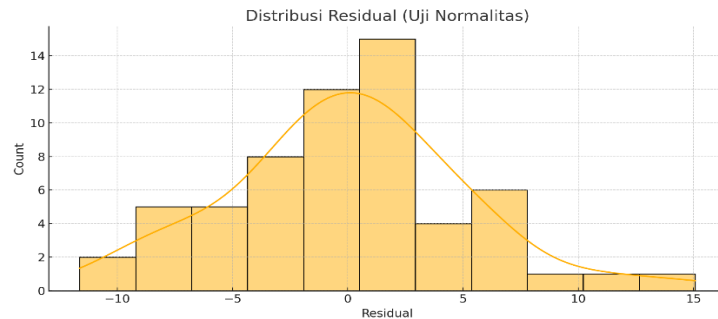


Figure 1. Results of the Normality Test

Normality testing of residuals was conducted to ensure that the residuals from the regression model were normally distributed, as required in classical linear regression analysis. The assessment was carried out by examining the residual histogram accompanied by a normal distribution curve, and further supported by skewness and kurtosis statistics. The visualization results indicated that the residual distribution was approximately symmetrical, with a peak shape resembling that of a normal curve. The skewness value of 0.254 suggests that the

distribution is not significantly skewed to the left or right, while the kurtosis value of 3.531 falls within the acceptable range for normal distribution (ideally close to 3). Moreover, the Jarque-Bera test yielded a probability value of 0.510 ( $p > 0.05$ ), indicating no significant deviation from normality. Based on these results, it can be concluded that the residuals in the regression model are normally distributed, thus fulfilling the assumption of normality and validating the model for further hypothesis testing.

Tabel Hasil Uji Multikolinearitas (VIF)

	Kelompok	Pretest Score
VIF	1.00	1.00

Variabel

Figure 2. Results of the Multicollinearity Test

Multicollinearity testing was conducted to determine whether there was a high linear correlation among the independent variables in the regression model. The presence of multicollinearity can lead to unstable regression coefficient estimates, making them difficult to interpret reliably. The analysis was carried out using the Variance Inflation Factor (VIF). The results showed that the VIF values for the variables 'group' and 'pretest score' were both 1.00, which is well below the commonly accepted threshold ( $VIF < 10$ ). This indicates that no high

correlation exists among the predictors included in the model. Therefore, it can be concluded that multicollinearity is not present, and the regression estimates can be considered statistically valid and interpretable.

The heteroscedasticity test aims to detect whether there is any inconsistency in the variance of residuals within the regression model. Such inconsistency violates the assumption of homoscedasticity and can affect the accuracy and reliability of parameter estimates. The analysis was

performed using the White Heteroscedasticity Test, which is capable of identifying heteroscedasticity

without requiring specific assumptions about the pattern of variance.

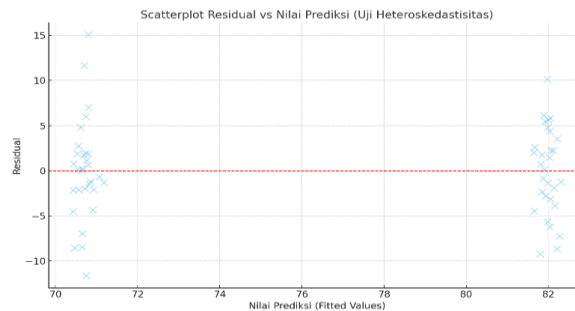


Figure 3. Results of the Heteroscedasticity Test

In this study, heteroscedasticity testing was conducted by visualizing the distribution of residuals against the predicted values from the regression model. The resulting scatterplot showed that the residuals were randomly dispersed around the horizontal axis (zero line) without forming any discernible patterns such as funnels, clusters, or curves. This distribution pattern indicates no systematic variance irregularities in the residuals. Therefore, it can be concluded that heteroscedasticity is not present in the regression model, and the assumption of residual variance stationarity is fulfilled.

Overall, the three classical regression assumptions have been satisfactorily met. These results provide a strong foundation indicating that the regression model used in this study is statistically sound. Consequently, the subsequent inferential analysis and interpretation of the effects of collaborative learning on students' problem-solving

abilities can be conducted in a methodologically valid and reliable manner.

### Statistical Testing

The results of the independent samples t-test revealed a highly significant difference in post-test scores between students in the experimental group and those in the control group. The experimental group, which participated in collaborative learning, achieved a mean post-test score of 81.98 (SD = 4.77), whereas the control group, which received conventional instruction, had a mean score of 70.71 (SD = 5.55). The statistical analysis yielded a t-value of 8.44 with a p-value of  $1.14 \times 10^{-11}$ , which is well below the standard significance threshold of 0.05. This result provides strong evidence that collaborative learning has a statistically and practically significant positive effect on students' problem-solving abilities.

Independent Samples Test					
Levene's Test for Equality of Variances		t-test for Equality of Means			
F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
.....	.....	.....	....	.....	.....
~0.01	0.92	8.44	58	.000	11.27

Figure 4. Results of the Independent Samples t-Test

The t-test was used to identify the partial effects of each independent variable on the dependent variable. Based on Figure 4, the results of the t-test indicate

that the relationship between variables can be mathematically represented through the following regression equation:

$$\text{Posttest Score} = 72.447 + 11.250(\text{Group}) - 0.028(\text{Pretest Score})$$

Constant (72.447): This value represents the hypothetical average posttest score for students in the control group (Group = 0) with a pretest score of 0. Although unrealistic in practice, this serves as the baseline intercept in the regression model. Group Coefficient (11.250): Students in the experimental group (who received collaborative learning) tended to score 11.25 points higher on the posttest than those in the control group, assuming pretest scores are held constant. This indicates a substantial positive effect of the collaborative learning model on students' problem-solving performance. Pretest Score Coefficient (−0.028): For each 1-point increase in pretest score, there was a slight decrease of 0.028 points in the posttest score. However, this result was not statistically significant ( $p = 0.800$ ), suggesting that initial ability did not meaningfully influence the final outcomes in this study.

The findings of this study indicate that students who participated in the collaborative learning model experienced a significant improvement in their problem-solving abilities compared to those who received conventional instruction. The posttest scores of the experimental group increased substantially, with a mean difference of over 11 points compared to the control group, as evidenced by the independent samples t-test results ( $p\text{-value} < 0.001$ ). These results affirm that collaborative learning is an effective instructional approach for enhancing students' higher-order thinking skills, particularly in the context of addressing complex problems. The structured interaction, peer collaboration, and reflective discussions embedded in the model appear to play a critical role in deepening students' cognitive engagement and problem-solving capacity.

The observed improvement can be strongly attributed to the role of social interaction in learning, which lies at the heart of Vygotsky's sociocultural constructivist theory. In collaborative learning settings, students actively engage in small-group interactions, supporting one another in

understanding and solving problems. This dynamic creates what Vygotsky referred to as the Zone of Proximal Development (ZPD)—a space in which learners can perform more complex tasks with the guidance of peers or facilitators than they could accomplish alone.

Within the ZPD, cognitive development is scaffolded through shared problem-solving and dialogic exchange. Contemporary research by Orr (2023) reinforces this theoretical framework, showing that peer collaboration and guided assistance significantly accelerate students' achievement of higher learning outcomes. This finding underscores the continued relevance of Vygotsky's theory in the context of 21st-century education, where collaborative competencies and adaptive thinking are increasingly vital.

Beyond mere cognitive achievement, interaction within collaborative learning environments also fosters the development of adaptive expertise—the capacity not only to master existing solutions but also to innovate in response to novel and complex situations. Through reciprocal interaction and argumentative discourse, students are encouraged to explore a variety of problem-solving approaches rather than relying on fixed procedures.

This aligns with the conceptual framework proposed by Hatano and Inagaki, who emphasized the importance of maintaining a balance between efficiency and innovation in the learning process. The collaborative model implemented in this study created such a space by engaging students in problem-based activities that emphasized collective reflection and intellectual flexibility.

From the perspective of contemporary instructional design, this strategy aligns closely with the principles of Problem-Based Learning (PBL) and the broader framework of active learning, both of which are central to current global efforts in higher education reform. Recent studies by Lee et al. (2023) and Guo et al. (2024) demonstrate that students' active engagement in problem-based tasks, combined with collaborative problem-solving, leads to substantial improvements in both cognitive and affective skill development. In this context, the

implementation of contextualized collaborative learning has proven effective in addressing the demand for a more participatory, reflective, and real-world-oriented educational experience. The findings of this study affirm the value of such approaches in cultivating deeper student involvement and meaningful learning outcomes within higher education.

The regression analysis conducted in this study further reinforces the theoretical arguments presented earlier. The “group” variable (collaborative vs. conventional learning) had a significant effect on posttest scores, whereas pretest scores did not contribute meaningfully to the outcome. This suggests that the type of instructional intervention plays a more decisive role in determining learning outcomes than students’ initial abilities. Collaborative learning, therefore, is not merely a means of facilitating information transfer, but a pedagogical approach that cultivates strategic and dialogic thinking. It encourages learners to engage in reflective problem-solving processes and shared meaning-making, which are essential components of higher-order cognitive development.

The validity of these findings is supported by the results of the classical assumption tests, which confirmed that the regression model met all analytical requirements: the residuals were normally distributed, no multicollinearity was detected among the predictors, and the residual variance was homogenous. Therefore, the model can be interpreted with statistical and methodological confidence, and the results can be considered a reliable representation of the empirical and theoretical impact of collaborative learning on students’ problem-solving abilities.

These findings are consistent with recent literature, such as the study by (Ramos & Yilmaz, 2023), which emphasizes that group work combined with individual accountability and socially responsible collaboration fosters deeper student engagement and positively contributes to cognitive development. Taken as a whole, collaborative learning not only yields statistically significant outcomes, but also reflects a model of education that

is inclusive, dynamic, and aligned with the direction of modern higher education transformation. It offers a framework that supports active participation, shared responsibility, and meaningful learning—core principles in advancing 21st-century pedagogical innovation.

Results should present the findings of your research in logical order. Present from the most important to less important of your data, with a clear and concise elaboration to make it easy to understand. Use past tense to explain your data, but avoid the interpreting or discussing the data. Do not duplicate data in different type, but summarize what readers will find in your data. Include a statistical analysis of your data, usually using p-value to show significant differences. Avoid hiding or keeping your data for separately another publication because this may lead to losing evidence to reinforce the conclusion.

This study makes a novel contribution by addressing both methodological and assessment gaps identified in prior research. Unlike earlier studies relying on less authentic measures, the present research employed Polya’s problem-solving framework, ensuring that the instrument captured not only recall but also analytical, strategic, and evaluative competencies. Combined with the quasi-experimental design, this strengthens the validity of the findings and provides a more comprehensive understanding of how collaborative learning enhances students’ problem-solving skills.

The discussion must be the interpretation of your results, clearly write what your results mean. This section is the most important part of your manuscript, discuss the data in order of the most to less important. Compare your results with other studies to convince your data if they are consistent. But if you find a work which is disagreement with yours, you must confront it to convince the reader that your data is correct or better. Discuss your data comprehensively by linking the data each other, to support your hypothesis. Explaining the weakness or limitation of your study may improve your manuscript quality by showing the readers that you have an in-depth understanding of your research and

thinking objectively.

Finally, emphasize your finding, what is new and why it is important, and suggest future studies that need to be carried out.

## CONCLUSION

Based on the analysis, it can be concluded that the collaborative learning model significantly enhances university students' problem-solving abilities. Students in the experimental group consistently outperformed the control group, with an average difference of over 11 points, as confirmed by a highly significant t-test result ( $p < 0.001$ ). The findings highlight that the instructional approach, particularly collaborative learning, plays a key role in improving problem-solving skills, rather than initial ability levels. These results support Vygotsky's sociocultural theory and the principles of Problem-Based Learning (PBL).

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