Edumatica: Jurnal Pendidikan Matematika
Volume 15 Number 3 December 2025

Submited : 26 April 2025
Revised : 27 October 2025
Accepted : 8 November 2025

DOI: https://doi.org/10.22437/edumatica.vl5i3.43491

Enhancing Mathematical Problem-Solving and Teamwork Skills For Junior High Schools Student Through Project-Based Learning

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Abstract

Problem-solving skills are not only correlated to academic success but also to increased competitiveness in a professional environment. However, many junior high school students have both weak mathematical problem-solving and teamwork skills. This study aims to describe the improvement of mathematical problem-solving and teamwork skills of students using the Project Based Learning (PjBL) model and scientific learning. This study is a quantitative study with a quasi-experimental method, using Pretest-Posttest Control Group Design. The population in this study consisted of 186 junior high school students in Bengkalis Regency. Data collection techniques were carried out through mathematical problem-solving ability tests and teamwork questionnaires. Data analysis was carried out using normalized gain (N-Gain) and one-way ANOVA. Based on the results of the data analysis, the results obtained were that students in the PjBL group showed a higher increase in problem-solving and teamwork skills with N-gains of 0.48 and 0.42, respectively, compared to the control class which obtained N-gains of 0.21 and 0.09, respectively. Teamwork skills consistently improved across all grades, while improvement in problem-solving skills varied according to students' initial abilities. This study supports existing research by integrating cognitive and affective aspects of problem-solving and financial literacy skills into everyday life.

Keywords: problem solving skill; project based learning; teamwork skills

INTRODUCTION

Problem-solving is a complex process that requires dynamic and flexible thinking and the use of various tactics to find appropriate solutions to the problems faced (Nicolay et al., 2023). Problem-solving skills are very important for students, because these skills train them to be better at analyzing and making decisions in life (Rahman, 2019). Research by Choupani et al. (2024) shows that problem-solving skills significantly predict work-life balance and work stress among workers. Research by Rosmayasari et al. (2024) which focuses on students' problem-solving skills in mathematics reveals that some students have difficulty understanding problem-solving strategies and mathematical operations, this makes problem-solving skills important to be developed from an early age. There are four stages in the problem-solving process: understanding the problem, creating a strategy or solution plan, implementing the plan, and reviewing (Daulay & Ruhaimah, 2019). Problem-solving skills not only encourage academic success but also improve work-life balance and increase competitiveness in a professional environment (Karla et al., 2022). Currently, research on problem-solving skills at the secondary school level has focused solely on cognitive aspects and has lacked integration of real-life group problems. This highlights a gap in the simultaneous application of problem-solving and teamwork skills.

In developing problem-solving skills, character values are also crucial in developing students' morals and character into individuals who are not only intelligent but also ethical and moral (Hermawan & Kusniasari, 2023; Zukhriya & Wijayanti, 2024). The Ministry of Education, Culture, Research, and Technology, through the Pancasila Student Profile program, strives to develop Indonesian students as lifelong learners who possess global competence and behave in accordance with Pancasila values (Githa et al., 2024; Mas et al., 2024). Strengthening the Pancasila Student Profile is crucial for shaping the character and morals of the nation's next generation so that they possess the noble values of the Indonesian nation (Nurhayati et al., 2022). The teamwork skills is one of the six Pancasila Student Profiles that aims to foster collaborative and community-oriented values among students (Luh De & Suastra, 2024). The practice of teamwork skills involves selfless cooperation for the common good and is considered essential for developing a strong sense of national identity and social responsibility (Erina & Manan, 2024). Educational programs needs to be designed to foster the values of teamwork skills in students, as they align with the Indonesian national character and are beneficial to their lives (Murtadlo et al., 2024; Rosida et al., 2024).

Various theories highlight the importance of mastering mathematical problem-solving skills and a teamwork skills. However, a preliminary study conducted by researchers in 2022 on 60 junior high school students in Bengkalis District found that 60% of students had poor mathematical problem-solving skills. In addition to mathematical problem-solving skills, the students' teamwork skills was also considered low. Problem solving and teamwork skills can be trained simultaneously through the application of appropriate learning models. According to Mery et al. (2022) one of the reasons of the decline in students' collaborative skills is also triggered by technological developments that encourage students to become more individualistic. This condition highlights the importance of integrating learning using contexts that are close to students' lives in order to train problem-solving skills and encourage teamwork.

Mathematical problem-solving skills should be a serious concern for teachers and educational institutions (Junitasari et al., 2021). All parties within educational institutions must also work together to address the decline in students' teamwork skills. Students must be directly confronted with contextual problems, encouraging them to think critically and find strategies to solve them. Strengthening the value of teamwork skills can be achieved through intra-curricular activities (Sumarsih et al., 2022). These activities include classroom learning and experiential learning activities (Megawati & Sari, 2021). In learning, students must face real world problems and learn to work together to solve them. The learning model which helps students to have an environment like this is project-based learning (PjBL).

Project-Based Learning (PjBL) is a learning model that uses projects or activities as the core of the learning process. The model of PjBL is considering that (1) students are dealing together with real life problem and to find solutions collaboratively first, then they gain knowledge (processors investigation) (Murtiyasa & Budiningsih, 2022). It also becomes the recommended model in

Independent Curriculum, especially for promoting the reinforcement of Pancasila Student Profile. In the recent educational paradigm, PjBL is encouraged to be implemented in order to help learning recovery as a character building that reflecting Pancasila values (Rachmawati et al., 2022). Based on a literature study conducted by Dewi (2023), it was found that PjBL is very suitable for improving the Pancasila Student Profile and training student collaboration.

A few studies have demonstrated beneficial effects of the application of PjBL. Student creativity, for example, improves considerably with the latter approach (Ummah et al., 2019). It has also been found that PjBL develops critical thinking and creativity in solving environmental problems (Sumarni & Kadarwati, 2020). Other studies suggest a significant association of PjBL with teamwork, as well as regular and authentic learning, which all lead to high student engagement, making this model highly recommended for use in education (Almulla, 2020; Mailok et al., 2016). The features of the PjBL model are that students accomplish the project assigned by cooperating or teamwork cooperation among all of their team members. The syntax of the Project-Based Learning model is: (1) preparing project questions or assignments; (2) designing project plans; (3) compiling project schedules; (4) monitoring project activities and progress; (5) testing results; and (6) evaluating activities or experiences (Sumarni, 2015).

Financial literacy is a mathematics subject closely related to everyday life. Research by (Darmayanti & Khairunnisa, 2024) shows that integrating financial literacy into the curriculum has a positive impact on student learning outcomes. Financial literacy needs to be practiced so that students can manage their personal finances confidently and make informed decisions (Kenayathulla et al., 2024). The financial literacy material in the previous curriculum was known as social arithmetic. Social arithmetic is the science that discusses economic transactions in everyday life that are solved using arithmetic applications. Financial literacy is a material that contains many problem-solving processes, so good problem-solving skills are required to master it. Financial literacy material plays a vital role in social life, such as trade, investment, and banking transactions. Mastery of this material is essential for ease in social life and the world of work.

Although numerous studies demonstrate the benefits of Project-Based Learning (PjBL) in enhancing creativity, critical thinking, and collaboration, there has been no research specifically exploring its application in financial literacy learning. Research examining the application of PjBL to simultaneously improve problem-solving and teamwork skills while considering prior mathematical abilities is still limited. Furthermore, the use of contextual problems that integrate local contexts is also limited. Therefore, this study was conducted to address this gap by applying the PjBL model to financial literacy materials that integrate local contexts into everyday life.

This study aims to examine the effect of implementing the Project-Based Learning model in financial literacy materials on improving mathematical problem-solving skills and mutual cooperation profiles based on students' prior mathematical abilities (KAM). This was done to determine whether students who received PjBL learning had greater improvement in these two skills compared to students who received learning using a scientific approach across all KAMs. This study explored not only the cognitive aspect of problem-solving skills but also the psychomotor aspect of teamwork skills. The learning tools in this study were designed in accordance with the Independent Curriculum which emphasizes student-centered learning and the development of Pancasila student profiles.

METHOD

Research Design

This research used a pretest-posttest control group design type of quasi-experiment for its quantitative method. It allows comparison of two groups, experimental and control, that both were pretested before the intervention and post-tested after the intervention. The experimental group was taught based on the PjBL model, and the control group was taught according to the scientific learning model in the Independent Curriculum. In this study, a pretest and posttest was completed by both control and experiment group before and after the intervention. The last test results for the experimental and control group were compared with statistical hypothesis testing to see whether there were any significant differences between both groups.

Research Subjects

The subjects of this research were students grade VII of SMP Negeri 1 Bengkalis, which is located in the Bengkalis district, Riau Province Indonesia Academic Year 2023/2024. The sample was determined by purposive sampling or at least based on certain targets and considerations (Sugiyono, 2019). The eligibility criteria were: (1) the use of the Independent Curriculum; (2) at least six classes being taught in seventh grade; and (3) an average class size of 30 or more students. SMP Negeri 1 Bengkalis is a junior high school that fulfilled these following criteria. Once the school was chosen, specific classes were selected over which the experimental and control groups could be constructed. The criteria of selecting class were: (1) normal level in students' academic performance; (2) homogeneity among the selected classes; (3) non-overlapped schedule for ensuring treatment not to be interfered by time conflicts.

SMP Negeri 1 Bengkalis has parallel classes of eight in grade VII. Scores were obtained for each day and class (8 classes) and statistically analyzed for normality and homogeneity between groups using SPSS. The data were both normally distributed and homogeneous between the classes as was confirmed by results. According to these results and schedule possibilities, three classes were chosen as experimental groups (VII-F, VII-G, and VII-H) while three others (VII-A, VII-B, and VII-C) were used as control. The sample size of the study was 186 students, which were about 31 students per class. The students have been classified in three ability groups (high, medium, and low levels) according to their scores on Initial Mathematical Ability (KAM), allowing for analysis of the impact of intervention approach in function of the initial level of school performance.

Data Collection Methods

For this study, two main tools were used to gather information: mathematics problem-solving test and teamwork skills questionnaire. The testing method was used to obtain information on the ability of students to solve problems. The test was repeated at two occasions: before the intervention (pre-test) and after the intervention (post-test). The sets of items for the pre- and posttest were not the same per se, but used different questions that are constructed using the same indicators and test blueprint such that difficulty levels and cognitive demands remained constant. Students' answers were assessed with a scoring rubric, constructed based on the indicators of mathematical problem solving skills: understanding of the problem, planning, and executing solution steps, and presenting the solution.

A questionnaire method was employed to capture students' teamwork skills. This approach required presenting a series of close-ended questions, to which participants had to select from predetermined fixed response categories offered by the investigator. The items were constructed using dimensions of the teamwork ability, which relates to collaborative action such as communication and responsibility or active participation in team work. When the individuals finished responding to the questionnaire, for each student, the sum of their responses (total score) was computed. The questionnaire was given to the students in two time periods just like the test: before and after an intervention.

Data Analysis Procedures

Several steps were carried out sequentially in this study to analyze the data. A preliminary goal was to quantitatively determine the level of the enhancement in mathematics problem solving and teamwork skills of students (in both groups). This was measured by the normalized gain (N-gain) formula which gives a normalized measure of learning gain from pretest to posttest. Prior to hypothesis testing, data analysis started with an inspection of the statistical assumptions required for validity of the specified parametric tests. This consisted of conduction a normality test via Student's t-test of the Kolmogorov-Smirnov test for pretest and posttest scores as well as performing them independently following the same criterion in SPSS. This was followed by a test for homogeneity of variance. For pretest data, an F test was performed and for posttest data, a Levene test was performed to determine the equality of variance between groups. After the results of the normality and homogeneity tests were met, a hypothesis test was conducted to see whether there were significant differences in student improvement results. The hypothesis test involved students' KAM so it was conducted using a one-way ANOVA test. A one-way ANOVA test was conducted to evaluate whether students with low, medium, and high KAM levels had significant differences in learning in the experimental and control classes. All statistical tests were conducted using SPSS to ensure the accuracy of the results obtained. The results obtained were used to evaluate the effectiveness of the PjBL model in improving mathematical problem solving skills and teamwork skills compared to the scientific approach.

RESULTS

Implementation of the Project-Based Learning Model in a Real-World Setting

The PjBL model was implemented to improve students' mathematical problem-solving and teamwork skills through three financial literacy-themed projects. Each project was designed to be contextual, relevant to students' lives, and aligned with 21st-century competencies. The following subsections explain the implementation and outcomes of each project.

First Project: Calculating Local Business Profits

For the first project, students were tasked with calculating the profits of a local business. In this activity, students explored material on purchase price, selling price, profit, loss, profit and loss percentage, and the concepts of gross, net, and tare. This activity was conducted at a home-based business processing lempuk durian, a traditional food in Bengkalis Regency. Students were asked to create a documentation sheet as a project report. An example of a documentation sheet created by students is shown in Figure 1.

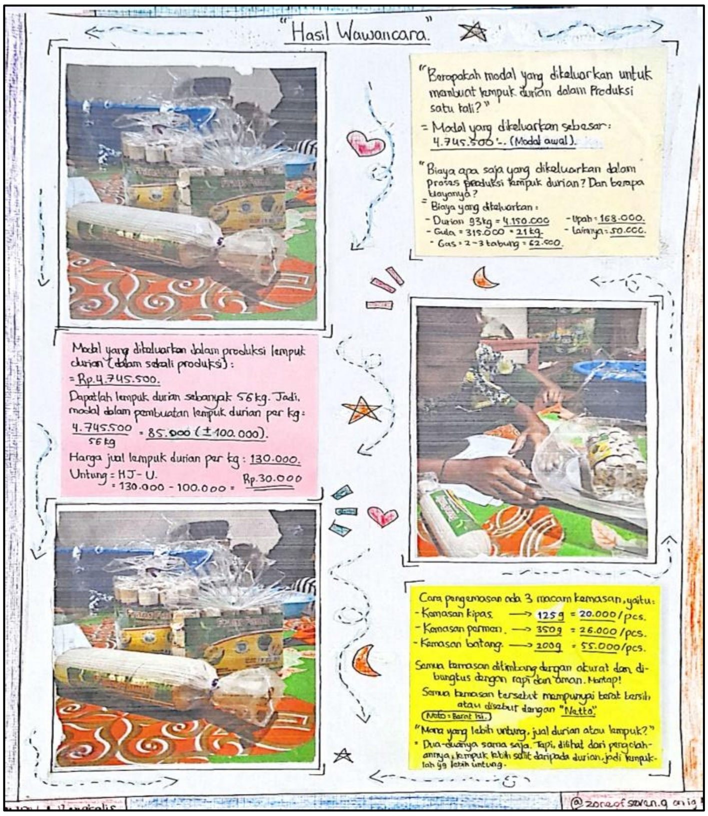

Figure 1. Students' First Project Documentation Sheet

Figure 1 shows that the first step the students took was to calculate the initial capital required to purchase components such as durian, sugar, gas, and employee wages. The price of each ingredient was recorded to determine the amount of initial capital required. In the second step, students analyzed the production results and selling price of the lempuk durian. In one production, lempuk durian entrepreneurs can produce 56 kg of lempuk durian. From the initial capital spent, students record the selling price to determine the amount of profit in one production. This activity encourages students to think that in running a business there are capital, selling price, and profit that must be taken into account. In the final step, students note that there are three packaging options for marketing lempuk durian to make it more attractive. In the bottom-right corner of Figure 1, students explained their packaging solution, there are three different packages. Every packaging style was properly weighed and finished aesthetically to suit the market. The concept of the net weight "Netto" was also cited in students' learning about product labeling and measurement accuracy.

The bottom reflection include an important consideration regarding the comparison of selling raw durian and lempuk durian, in which students found that although it is an easier process to sell durian directly, processing it into lempuk durian makes more money. This involves not only numerical analysis but also consideration of crucial decisions and entrepreneurial interpretation.

Students were required to work in small groups to budget, process, package, and present their result throughout the project. The activity was able to integrate cognitive skills (calculation, analysis), and affective skills (teamwork, responsibility) as it is in line with the goal of PjBL and Independent Curriculum framework. These results are in line with the study of Murtiyasa and Budiningsih (2022) as well as Priantari et al. (2020) posits that PBL promote dealing with problems, collaboration spirit and creative ideas.

Second Project: Discount Calculation in the Context of Retail Purchases

Figure 2 provides an example of the documentation on a PjBL activity concerning students' learning processes of discounts and price off in real situations such as their direct involvement at a store. Unlike conventional scientific learning, student could actively engage in a real purchasing activities, which help with strengthening these financial literacy competencies in an authentic context.

Figure 2. Students' Second Project Documentation Sheet

In the top section, students recorded what they learned from interviews with store workers, who cited discount stickers as commonly appearing on soaps, breads and dairy products that were close to expiration dates. It does not equalize and in fact remains above the store's purchase price, which means some profit regardless of discounting. This gave the students a little insight into elementary business operations and why discounts were given.

The middle passage records the students' working for two discounted items. The students found out how much it was and its sale price (to calculate the percentage discount). These had students using the % formula to find how discounts between actual shopping receipts and tags. The bottom part presents students with a budget of Rp20,000 and asks if they want to buy both items on sale, which costs them Rp16,200 (leaving a balance of Rp3,800). The point of the activity was to illustrate budgeting for needs, and how important it is to make informed choices when in a purchasing situation.

During the activity, students were able to apply essential financial literacy skills including recognizing markdowns, checking prices at the cashiers and discussing consumer behavior. Furthermore, they practice teamwork and communication through discussing or asking peers and shop assistants. The project not only supported mathematical problem solving in a dwelling place dimension, but also built sensitivities to economic decision-making that are grounded in everyday life experiences. This genuine learning occurs in the context of this community-based immersive experience reinforcing the idea that PjBL serves to reduce the gap between classroom-based and real-world application, thereby addressing both "cognitive preparation" and practical financial education needs for students.

Third Project: A comparison of Savings Interest and Profit Sharing

As opposed to the first two projects on tangible products and field purchase, for the third project students conducted interviews as part analytical study between the conventional bank interest system with Islamic bank profit sharing system. While visual documentation was limited due to space, students authentically engaged with banking practitioners throughout the project.

A representative from each team visited Bank Syariah Indonesia, Bengkalis District to gather information directly from bank officers about savings products, sharing profit schemes and how they were implemented. Bank employees handed out pamphlets, and explained how profit sharing percentages were calculated and different from a fixed bank interest rate.

Once they got back in the classroom, the representatives reported their discoveries to other members of their groups, allowing collaborative learning through peer interaction. The teacher also conducted a simulation calculation involving students comparing fixed conventional bank interests with variable Islamic interest rates, which depend on the bank's financial performance. From this simulation, students inferred that profit-sharing returns varied monthly, which in line with the company's profits, while traditional interest was fixed. This finding facilitated students in self-reflecting critically on how banking influenced both the economy and morality.

Indeed, some students mentioned sharing these findings with their parents and expressing a preference for Islamic banking because it was in line with both personal and religious values as well as its perceived equitable and co-operative-based method of doing business. This is an evidence on how PjBL does not only enhance students' conceptual knowledge, but also shape them to make value-based decision as it affects their real life financial perspectives. The execution of this project despite logistical constraints, highlights the fact that real learning is not limited to travelling for a full class to a field visit but can be efficiently achieved through focused interviews and sharing knowledge among peers. These findings are consistent with that of Bell and Dirgantoro (2023), that PjBL in students meaningfully contextualized learning and can connect classroom theory to practice. Therefore, and as the third work has confirmed a significant contribution on development of critical thinking, analytical reasoning and financial education this is evidence to support that project based learning actually works even in constrained conditions.

Mathematical Problem-solving Skill Improvement

Based on descriptive analysis, the average N-gain value of mathematical problem solving skills of each class is shown in Table 1 below.

Table 1. Average value of N-Gain

Class	Statistics			Treatment
	N	**Average N-Gain**	**Average N-Gain**	
VII-F	31	0.42		
VII-G	31	0.54	0.48	PjBL
VII-H	31	0.49		
VII-A	31	0.22		
VII-B	31	0.21	0.21	Scientifics
VII-C	31	0.20		

As shown in Table 1, the mean N-gain score of students' mathematical problem solving skills in the experimental class (N-gain = 0.48) is higher than those in control class (N-gain = 0.21). This slight improvement suggests that students who were taught under the PjBL model made more gains on their ability to analyze problems, design practices and apply math concepts when compared to the scientific learners. The gain represents not just procedural fluency, but also similar growth in understanding as students applied them during the course of contextual project based work which involved reasoning and reflecting. Improvements in students' competencies of mathematical problem solving across categories of KAM are also presented in Table 2 below.

Table 2. Average N-Gain KPMM for KAM Categories

KAM Category	Statistics		Treatment
	N	**Average N-Gain**	
High	16	0.71	
Medium	60	0.47	PjBL
Low	17	0.31	
High	16	0.32	
Medium	60	0.20	Scientifics
Low	17	0.13	

Table 2 offers additional information when considering the data by KAM category. The high KAM group had the largest increase (0.71), suggesting that learners' with higher prior knowledge could make most of the occasions of PjBL for higher-order thinking. This is in line with constructivist learning theories, which contend that students learn new knowledge most successfully when they possess a strong precursor to build on. It should be emphasized that even students of KAM-low and –medium were able to take a larger gain position, demonstrating that the PjBL model adequately helps those with various learning potentials.

The findings of one-way ANOVA test in line with the hypothesis proposed before to verify that "the increment on student mathematical problem-solving proficiency who learned by using project-based learning models differ from scientific learning at high, medium and low KAM level" can be seen in Table 3.

Table 3. One-way Anova Test Calculation of KPMM

	Df	**F**	**Sig.**	**Notes**
Between groups	2	27.329	0.000	
Within groups	183			H_0 rejected
Total	185			

As indicated by the results presented in Table 3, the calculated p-value is less than 0.05, which indicates that the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted. here is a significant difference in the improvement of students' problem-solving skills between the PjBL and scientific learning groups. This confirms that the learning model plays a significant role in improving problem-solving performance. The results of the one-way ANOVA test calculation, which was carried out to prove the hypothesis that there is a difference in the increase in mathematical problem-solving skills of students using the Project-Based Learning model between high, medium, and low levels of KAM, are shown in Table 4 below.

Table 4. One-way Anova Test Results of KPMM Test for Experimental Class Students

	Df	F	Sig.	Notes
Between groups	2	74.362	0.000	
Within groups	90			H_0 rejected
Total	92			

Based on Table 4, the calculated significance value is < 0.05, so H_0 is rejected while H_1 is accepted. This indicates that there is a difference in the increase in mathematical problem-solving skills of students using the PjBL model between high, medium, and low levels of KAM. This condition indicates that KAM influences the increase in students' mathematical problem-solving skills. All groups of students showed an increase in problem-solving skills, but students with higher KAM showed a higher increase than other groups. This indicates that PjBL can support differentiated learning with diverse student abilities.

Teamwork Skill Improvement

A subsequent analysis was conducted on the data of students' teamwork skill. The mean N-Gain value of the teamwork skill is displayed in Table 5 below.

Table 5. Average N-Gain Value of Teamwork Skill for Each Class

Class	Statistics			Treatment
	N	Average N-Gain	Average N-Gain	
VII-F	31	0.41		
VII-G	31	0.41	0.42	PjBL
VII-H	31	0.43		
VII-A	31	0.10		
VII-B	31	0.09	0.09	Scientifics
VII-C	31	0.09		

As shown in Table 5, the teamwork skill attainment for the experimental group (N-gain = 0.42) is significantly better than that of the control group (N-gain = 0.09). This suggests that students need to work together side-by-side only in the PjBL environment, so they have to communicate, make meaning negotiation, share efforts in project completion. This is consistent with the theoretical base of PjBL that emphasizes solving problems together and learning socially.

The enhancement of students' collaborative capabilities is additionally assessed within each KAM category. The mean N-Gain value of the teamwork skill for each KAM category is presented in Table 6 below.

Table 6. Average N-Gain Value of Teamwork Skill for Each KAM Category

KAM Category	Statistics		Treatment
	N	Average N-Gain	
High	16	0.41	
Medium	60	0.43	PjBL
Low	17	0.36	
High	16	0.10	
Medium	60	0.09	Scientifics
Low	17	0.11	

As illustrated in Table 6, teamwork skill gains are relatively consistent across KAM levels. Unlike problem-solving, this indicates that the development of teamwork skills is not strongly influenced by students' prior mathematical ability. This reinforces the idea that character-based competencies like teamwork are shaped more by the learning model and classroom culture than by initial cognitive ability.

The results of the one-way ANOVA test calculations were carried out to prove the hypothesis that there is a difference in the increase in the teamwork skill of students who use the project-based learning model with students who use scientific learning.

Table 7. Calculation Results of One-way Anova Test for Teamwork Skill

	Df	F	Sig.	Notes
Between groups	2	308.018	0.000	
Within groups	184			H_0 rejected
Total	185			

According to the findings presented in Table 7, the calculated value is greater than 0.05, which indicates that H_0 is rejected and H_1 is accepted. This indicates that there is a significant difference in teamwork skill improvement between the two learning models. PjBL has a stronger positive effect on teamwork development compared to scientific learning. The results of the one-way ANOVA test calculation, which was conducted to substantiate the hypothesis that there is a discrepancy in the increase in the teamwork skill of students who utilize the project-based learning model between high, medium, and low levels of KAM, are presented in Table 8 below.

Table 8. Calculation Results of One-way Anova Test for Teamwork Skill

	Df	F	Sig.	Notes
Between groups	2	0.650	0.525	
Within groups	90			H_0 accepted
Total	92			

According to the findings presented in Table 8, the calculated value is greater than 0.05, thereby supporting the null hypothesis (H_0) and refuting the alternative hypothesis (H_1). This indicates that there is no difference in the enhancement of the teamwork skill of students who utilize the project-based learning model, irrespective of their KAM status, whether high, medium, or low. This condition suggests that the KAM category does not exert an influence on the enhancement of the teamwork skill. The mean N-Gain value derived from the conclusion that KAM exerts no influence on student character is that the enhancement of character values is solely contingent upon the learning model implemented.

The findings of this research show that Project-Based Learning (PjBL) model is better than scientific learning in improving mathematic problem-solving and teamwork skills. The N-gain results indicate a certain augmentation in problem-solving skills of experimental students, explicitly of those entering the study with higher KAM (thus verifying that previous knowledge has an impact on cognitive improvement). On the contrary, teamwork skills increased significantly across all levels of ability, suggesting that collaborative practices are more influenced by learning models than students' initial academic background. In general, the findings of this study reveal double roles of PjBL both in improving cognitive skill as well as non-cognitive ones so it guarantees PjBL can be implemented as model learning which is relevant to student-centered learning and Pancasila Student Profile.

DISCUSSION

Analysis of the effect of implementing the PjBL Model on the development of Problem Solving Skills shows that the average increase in mathematical problem solving in the experimental group (N-gain = 0.48) clearly indicates the efficacy of the PjBL model in fostering critical thinking, analysis and transferable application driven mathematical concepts into real world situations. This result conforms to the general literature that indicates the ability of PjBL which would elicit students engaging in higher-order thinking skills when compared with a traditional scientific approach (Hossein-Mohand et al., 2021; Priatna et al., 2022). In particular, the real and contextualized projects created in this study are consistent with the pedagogical principles set out by Sumarni and Kadarwati (2020), who suggested that PjBL nurtures higher-level thinking through learning based on integrated active student-centered inquiry. In the same way, Lutfi and Sari (2025) showed that PjBL favors 21st century competences (collaboration – communication – critical thinking) by work not only with cognitive skills but also social skills based on a holistic education environment. The present results build on these earlier investigations by showing that the benefits are also present in relation to financial literacy, an under-researched subdomain of PjBL mathematics research.

Furthermore, due to the nature of PjBL based on inquiry, exploration and student-driven learning it lent itself well to critical thinking, analytical reasoning and self-directed problem solving. The findings show that students were not just following algorithms step by step, but reasoning, co-constructing meaning and using mathematical models to make sense of everyday phenomena. These findings support previous researches' conclusion that PjBL enhances students' skills in transferring mathematical knowledge to new situations (Hossein-Mohand et al., 2021; Priatna et al., 2022).

KAM analyses indicated the greatest gains for students with established ability (average N-gain = 0.71). Consistent with the N-gain results, Manurung et al., (2022) discovered high KAM students at least appear improved problem solving mathematics ability than medium and low KAM. This result is consistent with the findings of Priantari et al. (2020) who found that students with a high level of background knowledge are more likely to benefit from inquiry-based and constructivist pedagogies like PjBL. The differential effect between KAM levels indicates that PjBL not only has an overall beneficial effect on learning, but also helps provide differentiated instruction according to readiness level. It also supports the belief that PjBL could offer additional adaptive cognitive scaffolding, while students at varying levels of proficiency may all work on the same project, they can grow in their abilities to different degrees and at their own rate.

In terms of affective results, data also shows a remarkable progress on teamwork skills in students, with average N-gain for experimental group is 0.42. This enhancement was consistent at the different proficiency levels of mathematical ability and indicates that character dimensions such as responsibility, communication, and cooperation are not strongly influenced by academic starting points, but rather a characteristic of one's learning environment. These findings are consistent with Monika et al. (2023) who has reported the improved cooperative behavior resulting from PjBL worked in as cultural value, and Erina and Manan (2024), who have connected group-based projects on developing the teamwork skill.

Interestingly, ANOVA results reveal that team work skills were not significantly different across different KAMs levels in contrast to cognitive skills. This means that cognitive performance can be reliant on students' prior knowledge, character development —especially teamwork— is more responsive to the learning design. The collaborative nature of PjBL learning —sharing responsibilities, discussing, and reflecting as a team— provides fair opportunities for all students, regardless of their academic abilities. Such observations were consistent with the work of Sagita et al. (2022), who found that project-based learning greatly enhances collaboration, critical thinking and positive attitudes regardless of student abilities. Similarly, Sappaile et al. (2025) asserted that 21st-century competencies like collaboration and communication are fostered among students in PjBL regardless of their academic status.

Overall, the findings support the hypothesis that PjBL is an effective model for improving both cognitive (mathematical problem-solving) and affective (teamwork) outcomes in junior high school mathematics. These findings reinforce the multidimensional value of PjBL not only as an instructional tool but also as a character-building framework. This is consistent with Nurhasanah et al. (2024), who found that PjBL developed numeracy and self-efficacy among junior high school students, again supporting its effects beyond academic outcomes. This practice is also in line with what the Independence Curriculum emphasizes, that is to link conceptual understanding and student profile through a meaningful, student-centered teaching and learning perspective (Rahayuningsih et al., 2022).

Importantly, this study expands current understanding of the application of PjBL in the context of financial literacy (which is less explored in junior secondary education). Complex mathematical ideas were incorporated into real life financial choices such as saving and expense planning, and profit analysis so that the students could perceive the applicability of mathematics to their live. Hau et al. (2025) emphasized that integrating experiential financial activities into mathematics learning improves students' financial understanding and decision-making skills. Likewise, Kusumawati et al. (2023) highlighted the benefit of embedding economic reasoning into classroom instruction to support real-world money management skills. This directly supports the vision of mathematics education that goes beyond calculation, emphasizing critical decision-making and civic literacy.

CONCLUSION

In this study, which aims to analyze the effectiveness of a PjBL model on students' mathematical problem-solving and teamwork skills compared with a Scientific learning for both high and low-achieving students in an initial mathematics level (KAM). Evidence is provided to suggest that students who were taught with the PjBL design registered a greater increase in both competences at all levels of KAMs. In particular, the analysis results of N-gain indicated that PjBL contributed to enhancement of mathematical problem solving and teamwork skills (i.e., 48% improvement on mathematical problem-solving skills by PjBL and 42% improvement in teamwork ability). Students with high KAM showed the highest gain on problem-solving skills, and students with medium KAM showed the most improved teamwork skills.

These results support the applied use of PjBL in mathematics teaching, especially for subject matter necessitating both cooperation and reflection. In theory, this research contributes to constructivist learning theories of learning that emphasize active and situated learning. Nonetheless, the present study's sample was culturally-bound and the intervention period short, thus possible challenges to generalizing these findings. Implications for future research will include long-term application of PjBL in other subjects and grades with regard to effects on various student competencies, as well as widening the range of assessment instruments in order to gain more insight into its pedagogical impact.

ACKNOWLEDGMENTS

This research was conducted at SMP 1 Bengkalis, involving 186 students. The researcher would like to thank the active participation of students in carrying out the project. Appreciation is also expressed to several community business units that have provided their business premises for student learning facilities through projects.

DECLARATIONS

Author Contribution	:	Author 1: Conceptualization, Writing – Original Draft, Visualization, and Project Administration Author 2: Conceptualization, Methodology Design, Writing – Review & Editing Author 3: Data Collection, Data Curation, Formal Analysis Author 4: Writing – Review & Editing, Proofreading, and Draft Refinement Author 5: Writing – Review & Editing, Language Checking, and Final Manuscript Preparation
Funding Statement	:	This research was self-funded by the researcher
Conflict of Interest	:	The authors declare no conflict of interest.
Additional Information	:	Additional information is available for this paper.

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