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# Enhancing Collaboration and Problem-Solving Skills: The Role of Blended Project-Based Learning

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**Abstract**

The ability to collaborate and solve problems is essential for students facing 21st-century learning challenges. However, these skills are often underdeveloped in conventional classroom settings. This study aims to investigate the effect of blended project-based learning (BPjBL) on students' collaboration and problem-solving skills. A quasi-experimental method was used. The research was conducted at SMA Negeri 1 Sungkai Utara, North Lampung Regency, during the 2023/2024 academic year. The population comprised five science classes (XI IPA 1–XI IPA 5), with a total sample of 55 students selected through cluster random sampling. Class XI IPA 2 (28 students) served as the experimental group, while class XI IPA 3 (27 students) served as the control group. Data were collected using a problem-solving ability test, collaboration skill observation sheets, and learning implementation instruments. The results showed that the BPjBL model had a significant effect on students' collaboration skills ($p = 0.005 < 0.05$) and problem-solving abilities ($p = 0.007 < 0.05$). These findings indicate that integrating blended and project-based approaches can meaningfully enhance key 21st-century competencies. This study contributes to the growing body of evidence supporting active learning models and suggests that BPjBL can be effectively implemented in senior high school. These results suggest that BPjBL can be a useful teaching method for promoting critical 21st-century skills and should be considered in curriculum development for science education.

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## INTRODUCTION

In the 21st century, the direction of global education has shifted towards the development of complex cognitive and interpersonal skills, in line with the demands of globalization and the knowledge-based economy. The rapid advancement of technology has further emphasized the need for educational approaches that cultivate soft skills in students as part of the competencies required in this era (Syahputra, 2022). According to the National Education Association, essential 21st-century soft skills are encapsulated in "The 4Cs," which include creative thinking, critical thinking and problem solving, effective communication, and collaboration (Chiruguru & Chiruguru, 2020; Kivunja, 2015; Redhana, 2019).

Problem-solving skills are a core competence that must be fostered in students to prepare a competitive and high-achieving generation capable of facing 21st-century challenges (Alturki & Aldraiweesh, 2023; Mutohhari et al., 2021; Nilimaa, 2023). These skills encourage students to formulate appropriate strategies for addressing various

problems (Simanjuntak et al., 2021). Solving problems requires collaborative skills, as individuals must possess soft skills that support the development of problem-solving abilities in real-life contexts. Collaborative competence is vital for enabling students to work effectively in teams, a necessity in the era of globalization (Dewi et al., 2024; Farhurohman et al., 2025; Thornhill-Miller et al., 2023).

Collaboration in the learning process is characterized by cooperation among individuals who assist and complement one another to complete specific tasks and achieve shared goals (Lakkala et al., 2023). Moreover, collaborative abilities contribute to character development, as effective teamwork fosters a sense of responsibility within each student (Zitha et al., 2023). Therefore, selecting appropriate instructional models is a crucial step in enhancing students' problem-solving and collaborative skills in the learning process.

To address the current challenges in education, the Blended Project-Based Learning (BPjBL) model—an integration of Project-Based Learning and Blended Learning—employs information technology as a primary medium for instruction and emphasizes the creation of a final product as a tangible outcome of the learning process. Blended project-based learning synergizes the constructivist and experiential nature of project-based learning with the flexibility and accessibility of blended learning environments (Alamri, 2021; Mursid et al., 2022). This model encourages students to collaboratively engage in complex, real-world projects while utilizing digital platforms to expand interaction, access information, and receive feedback—all of which are conducive to the development of collaboration and problem-solving skills.

Unlike traditional project-based learning conducted solely in face-to-face settings, BPjBL integrates both asynchronous and synchronous digital tools to facilitate sustained collaboration and reflection. This model ensures that students participate in meaningful interactions both in person and online, thus fostering deeper understanding and sustained cognitive engagement, key factors in enhancing collaboration and problem-solving competencies.

Collaborative skills in BPjBL are cultivated as students are required to plan, implement, and present group-based projects (Hujjatusnaini et al., 2022b). These tasks necessitate negotiation, delegation, shared responsibility, and peer communication. Compared to students in conventional classrooms, those engaged in BPjBL have been shown to demonstrate enhanced group coordination and interpersonal communication skills (Purwianingsih et al., 2023). Technology-integrated BPjBL catalyzes high-quality collaboration (Mursid et al., 2022; Putra et al., 2021). It also offers an ideal context for enhancing problem-solving abilities by immersing students in open-ended, interdisciplinary challenges that simulate real-life situations (Hujjatusnaini et al., 2022b; Rahmawati & Atmojo, 2022). Students are expected to analyze data, evaluate alternatives, and draw evidence-based conclusions.

Research indicates that students taught through BPjBL significantly outperform those in control groups on standardized measures of collaborative behavior and structured problem-solving tasks. These outcomes are attributed to iterative feedback mechanisms and the diversity of resources available within blended learning environments.

Digital platforms used in BPjBL—such as Google Workspace, Microsoft Teams, and learning management systems like Moodle—play a crucial role in facilitating continuous collaboration beyond the physical classroom. These tools support shared documents, real-time discussions, and collaborative planning. Technology enhances the visibility of team progress and fosters a sense of responsibility and interdependence, which are central to collaborative learning (Kohn, 2024).

Well-structured BPjBL projects often include cycles of inquiry, reflective journaling, and peer evaluation components, all of which contribute to deeper problem-solving

engagement. When students are guided through structured inquiry within a collaborative environment, they are more likely to develop critical analysis, reasoning, and strategic thinking. The blended format allows these elements to be flexibly integrated into student schedules and personalized learning pathways.

Although the Blended Project-Based Learning (BPjBL) model has been widely recognized as effective in combining technology with active learning approaches to develop 21st-century skills (Hujjatusnaini et al., 2022a; Platonova et al., 2022), its application in formal education systems, especially in developing countries such as Indonesia, is still relatively minimal. This is because classroom learning is still dominated by lecture methods and memorization-based learning (Justice & Zhu, 2017; Rahmawati et al., 2021). Several previous studies have indeed demonstrated that BPjBL can enhance students' learning engagement and academic achievement, particularly in STEM subjects (Ma'wa et al., 2022; Mursid et al., 2021; Rasmitadila et al., 2020). However, not many have specifically examined how this model can develop students' collaboration and problem-solving skills. For example, the study by Tafakur et al. (2023) emphasized critical thinking skills, while the study by Aprita et al. (2014) focused on increasing learning motivation without impacting collaborative or problem-solving skills. This condition highlights a research gap that needs to be further explored regarding the effectiveness of BPjBL in enhancing 21st-century competencies, particularly at the secondary education level in Indonesia. Therefore, this study aims to make a meaningful contribution to the field of education by examining the direct impact of the blended project-based learning model on students' collaboration and problem-solving skills.

## METHODS

This study employed a quasi-experimental method using a Control Group Pretest–Posttest Design as the primary research design (Fraenkel, Wallen, & Hyun, 2012). The population of this study comprised eleventh-grade science students at SMA Negeri 1 Sungkai Utara in the 2023/2024 academic year, consisting of five classes: XI IPA 1, XI IPA 2, XI IPA 3, XI IPA 4, and XI IPA 5. The sample was selected using a cluster random sampling technique, wherein the classes were randomly assigned. As a result of the randomization process, class XI IPA 2 was designated as the experimental group, while class XI IPA 3 served as the control group. Prior to the intervention, a pretest was administered to both the experimental and control groups to assess their initial levels of collaboration and problem-solving skills. In addition, preparatory steps were taken, including training for the experimental class teacher on implementing the BPjBL model and orientation sessions for students regarding the use of online learning platforms.

To collect data, tests, observation sheets, and documentation were employed. The data were analyzed using multivariate analysis of variance (MANOVA), which is appropriate for comparing more than one dependent variable (Purnomo & Sutadji, 2022). The implementation of the BPjBL model in the experimental class followed five structured stages: project planning, digital collaboration, project execution, product presentation, and reflection. Students used platforms to support teamwork and communication. Meanwhile, the control group received traditional instruction consisting of lectures, textbook-based exercises, and individual tasks without collaborative projects or digital integration. This design ensured a clear contrast between the active, blended instructional method and conventional teacher-centered learning. The details of the students in classes XI IPA 2 and XI IPA 3 at SMA Negeri 1 Sungkai Utara are presented in Table 1, which shows the distribution of the research sample.

Table 1 Distribution of research sample

| Class | Male | Female | Total |
|---|---|---|---|
| XI IPA 2 | 9 | 19 | 28 |
| XI IPA 3 | 7 | 20 | 27 |
| **Total** | 55 | | |

The research sample consisted of 55 students, comprising 28 students from class XI IPA 2 as the experimental group and 27 students from class XI IPA 3 as the control group, as shown in Table 1. Prior to data collection, the research instruments were tested for validity, reliability, discrimination power, and difficulty level.

Validity testing was conducted to determine the extent to which the instrument accurately measures what it is intended to measure, using SPSS software. An instrument is considered valid if the correlation coefficient value exceeds the critical r-value of 0.224 at a 5% significance level with N = 55 (Arikunto, 2014). The results of the validity test are presented in Table 2.

Table 2 The result of the validity test

| Problem-Solving Skills | | | Collaboration Skills | | |
|---|---|---|---|---|---|
| **Indicator** | **Test Result** | **Legend** | **Indicator** | **Test Result** | **Legend** |
| Usefull description | 0.647 | Valid | Actively contribute | 0.561 | Valid |
| Physics Approach | 0.640 | Valid | Work productively | 0.727 | Valid |
| Specific to physics | 0.641 | Valid | Demonstrate a sense of responsibility | 0.547 | Valid |
| Mathematical procedure | 0.638 | Valid | Show flexibility and willingness to compromise | 0.584 | Valid |
| Logical progression | 0.647 | Valid | Show an attitude of mutual respect | 0.582 | Valid |

Based on Table 2, the validity test results show that each indicator's value in the results column exceeds the r-table value of 0.224, indicating that the research instrument is valid and suitable for use. Next, the reliability test can be conducted using various methods, such as Cronbach's Alpha, which measures internal consistency.

The reliability test aims to determine the internal consistency among items within a single instrument. The technique employed is Cronbach's Alpha, with the interpretation that an Alpha value greater than 0.70 indicates high reliability, while values between 0.60 and 0.70 are still acceptable within the context of exploratory research (Sugiyono, 2018). The reliability test results are presented in Table 3.

Table 3 The result of the reliability test

| No. | Variable | Cronbach's Alpha | Explanation |
|---|---|---|---|
| 1. | Problem-solving Skills | 0.641 | Reliable |
| 2. | Collaboration skills | 0.562 | Reliable |

Based on Table 3, the reliability test shows that the variable of problem-solving ability has a Cronbach's Alpha value of 0.641, while the collaboration skills variable has a value of 0.562. Therefore, both variables can be considered reliable. Next, the item discrimination test was conducted to assess the extent to which each test item can distinguish between students with high and low ability levels in answering the test.

The purpose of the discrimination test is to evaluate the ability of each test item to differentiate between students of high and low abilities. The technique used was the upper-lower group method based on scores, with the interpretation of correlation values as

follows: >0.40 is very good, 0.30–0.39 is sufficient, 0.20–0.29 is low, and <0.20 is poor (Arikunto, 2014). The results of the discrimination test are presented in Table 4.

Table 4 Result of item discrimination test

| No. | Correlations | Explanation |
|---|---|---|
| 1. | 0.373 | Moderate |
| 2. | 0.315 | Moderate |
| 3. | 0.227 | Moderate |
| 4. | 0.183 | Low |
| 5. | 1 | Excellent |

Based on Table 4, the item discrimination test for the problem-solving ability variable shows that item 1 has a value of 0.373, categorized as moderate; item 2 has a value of 0.315, categorized as moderate; item 3 has a value of 0.227, categorized as moderate; item 4 has a value of 0.183, categorized as poor; and item 5 has a value of 1.000, categorized as excellent.

The item difficulty test is a method used to measure the extent to which an item can be answered correctly by students, thereby classifying the item as easy, moderate, or difficult. Item difficulty is calculated based on the proportion of correct answers (p), with the following categories: $p > 0.70$ (easy), $0.30 \leq p \leq 0.70$ (moderate), and $p < 0.30$ (difficult) (Arikunto, 2013). Table 5 presents the results of the item difficulty test.

Table 5 Result of the item difficulty test

| Items | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| N | 55 | 55 | 55 | 55 | 55 |
| Missing | 0 | 0 | 0 | 0 | 0 |
| Mean | 2.60 | 1.93 | 1.91 | 1.89 | 1.96 |
| Explanation | Difficult | Difficult | Difficult | Difficult | Difficult |

Based on the difficulty level test results in Table 5, question 1 has a value of 2.6000, categorized as difficult; question 2 has a value of 1.9273, categorized as difficult; question 3 has a value of 1.9091, categorized as difficult; question 4 has a value of 1.8909, categorized as difficult; and question 5 has a value of 1.9636, also categorized as difficult.

## RESULTS AND DISCUSSION

This section presents the research findings. It includes students' proficiency in collaborative skills and problem-solving abilities through the Blended Project-Based Learning model, as well as the relationships between these variables.

### Pretest and Post-test Results for the Experimental and Control Groups

Based on the pretest and post-test results of the experimental and control groups on the problem-solving ability instrument involving 55 students, the data are presented in Table 6 below:

Table 6 Distribution of pretest and post-test data on problem-solving ability

| Data | Experiment Group | | Control Group | |
|---|---|---|---|---|
| | Pretest | Post-test | Pretest | Post-test |
| Highest Score | 70 | 89 | 65 | 85 |
| Lowest Score | 30 | 45 | 0 | 0 |
| Mean | 35.50 | 75.85 | 51.5 | 55 |
| Median | 54 | 75.5 | 45 | 53.4 |
| Mode | 30 | 55 | 35 | 42 |

The results indicate an increase in the average post-test scores of the experimental group compared to the control group, suggesting a positive effect of the Blended Project-Based Learning (BPjBL) model on students' problem-solving abilities.

**Prerequisite Analysis Testing**

A normality test was conducted to examine whether the sample under study follows a normal distribution. The results of the normality test are presented in Table 7.

Table 7 Results of the normality test

| Aspect | Test Type | Class | Sig. | Description |
|---|---|---|---|---|
| Problem-Solving Collaborative | Kolmogorov-Smirnov | Experiment | 0.132 | Normal |
| | | Control | 0.186 | Normal |
| | | Experiment | 0.063 | Normal |
| | | Control | 0.196 | Normal |

Based on the results of the normality test in Table 7, all significance values are greater than 0.05, indicating that the data are normally distributed. Subsequently, a homogeneity test was conducted using Levene's Test to determine the equality of variances between the experimental and control groups.

The homogeneity test was conducted to determine whether the variances between the experimental and control groups are equal. This test is essential for determining the appropriate statistical analysis method to be used. The results of the homogeneity test are presented in Table 8.

Table 8 Results of the homogeneity test

| Variable | Levene Statistic | Sig. | Description |
|---|---|---|---|
| Problem-Solving Ability | 1.148 | 0.128 | Heterogeneous |
| Collaborative Skills | 2.450 | 0.123 | Heterogeneous |

Based on Table 8, the significance values indicate that the problem-solving variable yielded a value of 0.128, which is greater than 0.05, and the collaborative skills variable yielded a value of 0.123, also greater than 0.05. These results indicate that the variances of the post-test data between the experimental and control groups are unequal or heterogeneous. However, the data still meet the assumptions required for further analysis using MANOVA.

**Hypothesis Testing (Multivariate Analysis of Variance)**

Multivariate analysis of variance is a statistical test used to compare variance across more than one dependent variable. The selection of Multivariate Analysis of Variance (MANOVA) in this study was based on the need to analyze the effect of the Blended Project-Based Learning (BPjBL) model on two dependent variables simultaneously, namely students' collaborative skills and problem-solving abilities in Grade XI of senior high school. MANOVA was chosen because it allows for the simultaneous testing of mean differences across multiple dependent variables, thus enabling a more comprehensive identification of both main effects and potential interactions among the variables compared to univariate ANOVA.

Considering the complexity of the data and the interrelationship between collaborative skills and problem-solving ability, MANOVA is deemed the most appropriate statistical method to test the research hypothesis with higher accuracy. The results of the MANOVA test are presented in Table 9.

Table 9 Results of MANOVA test

| Source | Dependent Variable | Type III Sum of Squares | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| BPBL | Problem-solving | 6.943 | 83.471 | .716 | 0.007 |
| | Collaboration | 26.709 | 113.354 | 3.389 | 0.005 |

Based on the MANOVA output presented in Table 9, the significance value of the Blended Project-Based Learning (BPjBL) model on collaborative skills was 0.005 < 0.05, indicating that H0a is rejected and H1a is accepted. This suggests that the BPjBL model has a statistically significant effect on students' collaborative skills. Furthermore, the significance value of the BPjBL model on problem-solving ability was 0.007 < 0.05, leading to the rejection of H0b and acceptance of H1b. Therefore, it can be concluded that the BPjBL model has a significant influence on students' problem-solving abilities.

These findings indicate that the BPjBL model significantly enhances students' ability to solve problems and collaborate effectively. The results are supported by the MANOVA analysis, which shows significance values below 0.05 for both variables, indicating a meaningful effect of the BPjBL model implementation.

Theoretically, this model is rooted in the constructivist approach (Piaget, 1950), which posits that learners construct knowledge through direct experiences and social interaction. Project-based learning offers an environment for active engagement, teamwork, and the contextual resolution of complex problems (Bell, 1993). Meanwhile, the blended learning approach facilitates more flexible and independent learning while also reinforcing both synchronous and asynchronous interactions through digital platforms (Michael, 2013).

The results of this study indicate that the BPjBL model can enhance students' problem-solving and collaboration skills, as it directly engages them in completing challenging and real-life-related tasks. These findings are in line with previous research by Tafakur et al. (2023), which showed that project-based and context-based learning approaches can develop students' critical thinking skills. This study also supports the findings of Hujjatusnaini et al. (2022) and Platonova et al. (2022), who reported that BPjBL is effective in promoting active engagement and higher-order thinking, especially when technology is used appropriately. In addition, unlike earlier studies that only focused on learning outcomes or motivation (such as Aprita et al., 2014), this research provides deeper insight by using direct observation and performance-based assessments to measure collaboration skills. From a theoretical perspective, these results support constructivist learning theory, which emphasizes that learning happens through real experiences and social interaction, as well as Bandura's social-cognitive theory, which highlights the importance of learning through cooperation and observation. In contrast to many previous relevant studies, this research employed both observation instruments and performance-based assessments of collaborative skills, providing a more in-depth and classroom-based contextual analysis.

Conducted within the context of senior high school education in Indonesia, this study focused on the simultaneous measurement of two socio-cognitive skills within a single BPjBL model design, an area that remains underexplored. Thus, the study offers a novel contribution by presenting empirical evidence of the comprehensive and contextual effectiveness of the BPjBL model. However, this study has some limitations, such as a small sample size and being conducted in only one school. Therefore, further research with larger samples and in different school settings is needed to see whether similar results can be achieved in other contexts.

## CONCLUSION

This study demonstrates that students' collaborative and problem-solving skills were significantly enhanced through the implementation of the Blended Project-Based Learning

(BPjBL) model. The MANOVA analysis results showed a significance value of 0.007 for problem-solving and 0.005 for collaboration—both below the 0.05 threshold—indicating that BPjBL has a statistically significant effect on both abilities. The average problem-solving score of the experimental group increased from 35.50 (pretest) to 75.85 (post-test), while the control group only improved from 51.5 to 55. The average collaborative skill score in the experimental group rose from 58.30 to 82.70, whereas the control group improved from 48.90 to 57.00. These findings confirm that BPjBL is effective in supporting students in solving problems through critical thinking, active learning, and cooperative work, with greater improvement evident in the experimental group.

The main focus of this study was to assess two key 21st-century skills, collaboration and problem-solving, within the context of science education at the senior high school level. The adopted approach integrated face-to-face and digital learning, enabling a more contextual and flexible learning process. The results indicate that BPjBL can be recommended as an effective alternative instructional model to enhance students' socio-cognitive skills. This study also opens avenues for further research to explore the applicability and effectiveness of this model in other subject areas and across different educational levels.

Future studies may explore the long-term effects of BPjBL and how it can also enhance other social skills, such as communication and responsibility. Additionally, this model can be tested at various educational levels, such as junior high school or university, to assess its broader applicability. During the implementation of this study, one of the challenges encountered was ensuring that all students actively participated in group work, particularly when utilizing digital tools. To address this, initial guidance and short training sessions are recommended to help students become more comfortable with online project-based learning. These findings are expected to serve as a reference for teachers and education practitioners to begin adopting approaches that encourage students' active engagement in 21st-century learning.

## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

## AUTHOR CONTRIBUTION STATEMENT

The main theme of this study was initiated by AN and YS; AN carried out the development of the theoretical framework. The verification of the analytical methods, guidance provided to AN during the research process, and supervision of the data analysis were conducted by RD and YS. All authors participated in the discussion of the findings and contributed to the final manuscript.

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