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The Effect of PBL in Teaching at the Right Level Approach on Collaboration Skills and Student Learning Outcomes in Coordination System Material

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Abstract

Based on observations, students' collaboration skills and learning outcomes in the coordination system material remain low, while the implementation of Problem-based Learning (PBL) has not been optimal. This study aims to analyze the effect of PBL in the Teaching at the Right Level (TaRL) approach on students' collaboration skills and learning outcomes. The study employed a quasi-experimental method with a Nonequivalent Control Group Design. The sample consisted of two eleventh-grade biology classes: the control class applied PBL without differentiation, while the experimental class applied PBL-TaRL based on learning styles. Data were analyzed using t-test and N-gain. The results showed that the experimental class achieved higher improvement in collaboration skills than the control class, with the final category being "excellent" and N-gain at a moderate level, while the control class was in the "good" category with moderate N-gain. Learning outcomes also improved, as indicated by the posttest mean score of the experimental class (74.86), which was higher than the control class, with a moderate N-gain. The t-test yielded a significance value of 0.046 < 0.05. Thus, the implementation of PBL-TaRL is effective in enhancing students' collaboration skills and learning outcomes.

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INTRODUCTION

The 21st-century skills pose a challenge in education in Indonesia. The 21st-century learning skills apply to student-centered learning. 21st-century learning skills consist of collaboration, communication, critical thinking and problem solving, and creativity and innovation (Fitriyah & Bisri, 2023). Teachers must be able to meet the challenges of the 21st century in terms of skills and qualifications that align with the implementation of the independent curriculum (Maulidia *et al.*, 2023). The implementation of the independent curriculum is accompanied by the strengthening of the Pancasila student profile, which consists of six dimensions: 1) faith and piety toward God Almighty, 2) independence, 3) cooperation, 4) global diversity, 5) critical thinking, and 6) creativity (At'Haya *et al.*, 2023). The independent curriculum provides students with the freedom to learn through their individual characteristics, both in cognitive and non-cognitive abilities. The implementation of the independent curriculum in the learning process facilitates each student's characteristics in learning activities.

Based on observations and interviews, teachers revealed that students still have difficulty understanding biology material related to human physiology, one of which is the coordination system. The coordination system material is complex and requires students to be more actively involved in understanding the concepts. The coordination system material contains complex concepts, such as the working mechanisms of the nervous and hormonal systems and their relationship with the sensory organs, thus requiring learning strategies that are not only teacher-centered. The results also show that the application of the PBL model was carried out through the provision of worksheets containing questions to test students' understanding, so that students only focused on answering questions without any problem-solving activities that encourage critical and collaborative thinking skills, which resulted in low student learning outcomes and collaboration skills. The problems found indicate that in the coordination system material, a strategy is needed that can optimize the application of PBL so that students not only work on questions but are also effective in understanding concepts through collaborative problem solving. This study provides a solution in the form of applying PBL in the Teaching at the Right Level (TaRL) approach.

This solution provides students with the opportunity to learn in a way that suits their learning style, which is expected to encourage students to actively engage in discussions, problem-solving, and group work. The PBL model uses real-world problems as a basis for developing knowledge and concepts in students. In the PBL model, students are required to systematically and gradually identify real problems to obtain information related to the topic (Setiawan & Suwarsi, 2024). Research conducted by Isma *et al*. (2021) shows that the application of the PBL learning model can improve student learning outcomes. Improvements in student learning outcomes can occur through a high level of understanding of the subject matter. Through problem-solving activities, students can be trained to use their critical thinking skills to find solutions to problems. Students engage in various activities that train critical thinking skills by developing problems to be discussed in learning, interpreting phenomena around them, and drawing conclusions based on relevant theories as their framework of thinking (Sukaesih *et al*., 2022). The implementation of the PBL model helps teachers facilitate students' learning both individually and in groups (Ramadhani *et al.*, 2024). Teachers facilitate students' learning needs through the TaRL approach, which is based on differentiated learning based on student characteristics. The application of PBL in the TaRL approach is carried out with differentiation that is adjusted to students' learning styles, taking into account students' tendencies to learn visually, auditorily, or kinesthetically. Fauzi *et al*. (2023) revealed that the learning process becomes more efficient and effective through learning methods that suit students' learning styles. Each student has different characteristics, so learning strategies that are adjusted to learning styles can help students more easily understand complex material. Presenting real problems to students in accordance with their learning styles provides opportunities for students to understand material concepts through problem-solving. The application of learning style-based differentiation in the PBL model facilitates students to be actively involved in group discussion activities and motivates them to participate in problem-solving.

Based on the background, it is necessary to conduct a study on the effect of PBL in the Teaching at

the Right Level approach through differentiated learning based on learning styles on students' collaboration skills and learning outcomes in the subject of the coordination system. The purpose of this study is to analyze the effect of implementing the Problem-Based Learning (PBL) model in the Teaching at the Right Level (TaRL) approach on students' collaboration skills and learning outcomes in the subject of the coordination system. Students' collaboration skills were obtained based on the results of a self-assessment questionnaire with indicators of collaboration skills according to Valente (2018), namely 1) focus on tasks; 2) helping each other; 3) responsibility and trust; and 4) team performance. Student learning outcomes were obtained based on the results of a test on the coordination system material, which was compiled based on Bloom's Taxonomy cognitive indicators, namely remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creating (C6). Both classes used the PBL learning model, with the experimental class applying the PBL model integrated with the TaRL approach through differentiated learning based on student learning styles. The PBL model applied referred to the 5 stages of PBL by Arends (2015): 1) orienting students to the problem, 2) organizing students for study, 3) guiding investigations individually and in groups, 4) developing and presenting problem-solving procedures and solutions, and 5) analyzing and evaluating the entire process.

RESEARCH METHOD

The study was conducted at SMA Negeri 3 Pekalongan in the even semester of the 2024/2025 academic year. The population was all eleventh-grade students. The sample was determined using purposive sampling with criteria: students majoring in biology and taught by the same teacher. Classes XI-6 and XI-7 were selected, each consisting of 36 students. Class XI-6 was assigned as the experimental class receiving the PBL-TaRL model, while class XI-7 served as the control class receiving PBL without differentiation. The implementation of PBL-TaRL began with a diagnostic assessment used to form groups based on learning styles. Differentiation was applied in two stages: content differentiation at "Orienting students to the problem" and process differentiation at "Organizing students to learn." Research instruments consisted of a validated collaboration skills questionnaire and a 20-item multiple-choice test on coordination system concepts. Validation was carried out by expert judgment. Data were analyzed using the N-gain test to measure improvement and the independent samples t-test to examine the significance of differences between groups.

RESULTS AND DISCUSSION

The implementation of PBL-TaRL encouraged students to engage actively in each stage of learning, from problem orientation to reflection. This process provided opportunities to collaborate, share responsibilities, and explore materials according to their learning styles, which is reflected in the results presented below.

Collaboration Skills

Students' collaboration skills improved on average after the learning process using the coordination system with the application of the PBL model. The results of the collaboration skills questionnaire for both classes are presented in **Table 1**.

Table 1. Results of Student Collaboration Skills Measurement

	Experimental Class		**Control Class**	
Measurement	Initial	Final	Initial	Final
Lowest	64	73	64	73
Highest	86	100	93	100

Average	76,42	88,36	74,47	84,83

Table 1 shows the results of the collaboration skills questionnaire with an increase in the average score. The results in the experimental class had a higher average score than the control class, from 76.42 to 88.36. The control class, which applied the PBL learning model, also had an increase in the average score from 74.47 to 84.83. Although there was an increase in both classes, the average increase in the experimental class was higher than that of the control class. The results of measuring students' collaboration skills in the control class and experimental class were interpreted into the categories presented in **Table 2**.

Table 2. Percentage of Student Collaboration Skills Results in Each Category

Category	Experimental Class		Control Class	
	Initial	Final	Initial	Final
Excellent	6	69	8	50
Good	81	31	67	50
Fair	14	0	25	0

Table 2. shows the distribution of the number and percentage of students in the experimental class and control class based on categories in the initial and final measurements of collaboration skills. The initial measurement results in the experimental class showed that most students were in the "good" category with 81%, and 6% were in the "excellent" category. The final measurement data showed an increase in collaboration skills in the experimental class, with 69% of students in the "excellent" category and no students in the 'fair' category. Meanwhile, the final measurement results for the control class showed an increase, with 50% of students in the "excellent" category. Collaboration skill measurements were also analyzed on average for each indicator in the initial and final measurements. The results obtained for each indicator in both classes are described in Figure 1.

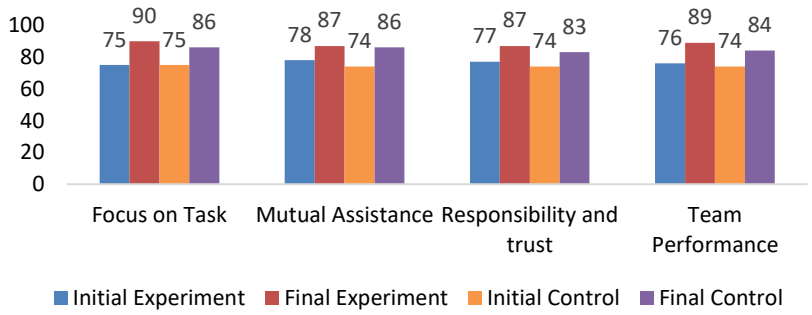

Figure 1. Comparison of Initial and Final Measurement Results of Student Collaboration Skills on Each Indicator

In Figure 1, all indicators of collaboration skills show an increase in average scores from the initial measurement to the final measurement. In the experiment class, the indicator with the highest increase is the "focus on tasks" indicator, which increased by 15 points from a score of 75 in the initial measurement to 90 in the final measurement. The "team performance" indicator also showed a significant increase of 13 points, from 76 in the initial measurement to 89 in the final measurement. The "mutual assistance" indicator increased by 9 points from 78 to 87, and the "Responsibility and trust" indicator increased by 10 points from 77 to 87.

The improvement in students' collaboration skills between the control class and the experimental class was determined through the N-gain test. The N-gain test results for self-assessment of collaboration skills are shown in **Table 3**.

Table 3. N-gain Test for Collaboration Skills in the Experimental Class and Control Class

	Average pretest	Average posttest	N-gain	Criteria
Control	74,47	84,83	0,42	Moderate
Experiment	76,42	88,36	0,51	Moderate

Table 3. shows that there is a similarity in criteria, the N-Gain value in both classes falls within the moderate criteria. The control class has an N-gain value of 0.42, while the experimental class has a higher N-gain value of 0.51. The analysis of the N-gain results for collaboration skills in both classes is supported by the total percentage of students in each N-gain criterion, as shown in **Figure 2**.

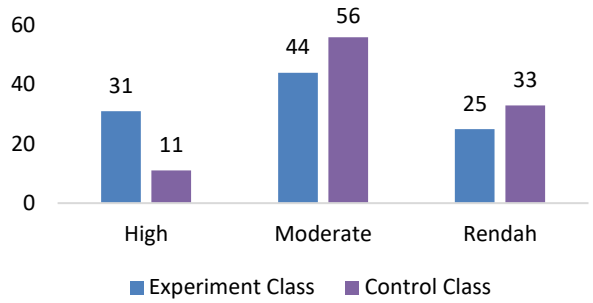

Figure 2. Comparison of the Percentage of N-Gain Test Results for Student Collaboration Skills

Figure 2. shows the distribution of students based on criteria in N-gain scores. In the control class, most students were in the moderate category, accounting for 56%, while 11% were in the high category. In the experimental class, 31% of students were in the high category, and the number of students in the low category was fewer than in the control class. The N-gain data for both classes indicate that more students in the experimental class experienced more optimal improvement in collaboration skills.

The students' collaboration skills were analyzed using a parametric test to determine the effect of the PBL-TaRL model on collaboration skills between the two classes. Based on the prerequisite tests, namely the normality test and the homogeneity test, the collaboration skill data were found to be normally distributed and had homogeneous variance, thus meeting the requirements for parametric testing. The parametric test conducted was the independent sample t-test, presented in **Table 4**.

Table 4. Independent Sample T-Test for Collaboration Skills

Independent Sample T-Test	Sig. (2-tailed)	Remarks
Measurement Initial	0,184	Not Significantly Different
Measurement Final	0,046	Significantly Different

The results show that the final measurement of collaboration skills indicates a significance value (2-tailed) of 0.046 < 0.05, which means that there is a significant difference in the collaboration skills of students in the control class and the experimental class. Therefore, it can be concluded that the PBL learning model

in the TaRL approach, which uses learning style differentiation, has a significant effect on students' collaboration skills.

The implementation of the PBL-TaRL model based on students' learning styles encourages students to collaborate in solving problems given in the LKPD according to the characteristics of each student's learning style. Alabi (2024) revealed that creating learning activities that suit different learning styles provides opportunities for teachers to create a learning environment that encourages students to participate actively, collaborate, and take responsibility for their learning process. The lower results in the control class may be due to the formation of heterogeneous groups, causing some students to experience difficulties in dividing group roles and responsibilities due to differences in abilities and learning styles. In some situations, heterogeneous groups can enrich discussions because students can help each other with their different abilities and characteristics, but in practice, the dominance of certain members and imbalances in student contributions can occur if group management is not optimal. Ningsih *et al.*, (2023) revealed that homogeneous groups tend to increase student activity and focus on learning due to similarities in characteristics, thereby positively impacting collaboration levels and learning outcomes. This aligns with findings showing higher achievement in collaboration skill indicators in the experimental class compared to the control class. Based on the results of collaboration skills, it can be interpreted that the application of the PBL-TaRL model based on students' learning styles contributes more optimally to the development of students' collaboration skills. This aligns with research conducted by Cahya *et al.* (2023), which states that the application of differentiated learning tailored to students' learning styles can be an effective learning strategy in enhancing students' collaboration skills in biology lessons.

Learning Outcomes

Student involvement and activity in learning not only develop students' collaboration skills, but also their motivation, which will have an impact on improving student learning outcomes. Student learning outcomes are measured using written tests in the form of pre-tests and post-tests on the coordination system material. The number of test questions administered is 20 multiple-choice questions.

Table 5. Student Pre-test and Post-test Results on Coordination Systems

	Experiment Class		Control Class	
	Pretest	*Posttest*	*Pretest*	*Posttest*
Lowest	20	50	15	60
Highest	65	100	40	100
Average	36,39	74,86	33,75	67,78
Achieved	0%	72%	0%	61%
Not Achieved	100%	28%	100%	39%

The pretest results showed that neither class was complete based on the Minimum Completion Criteria (KKM) set by the biology teacher at the school, which was 70. The experimental class experienced an increase in the post-test average score of 74.86 with a completion rate of 72%, while the control class had a post-test average score of 67.78 with a completion rate of 61%.

The control class also experienced a fairly good improvement, which was possible because both classes applied the PBL learning model. The PBL model provides learning experiences through collaborative activities and problem-solving that can encourage active student involvement. In the control class, the implementation of PBL was not accompanied by a differentiated approach, so students' learning styles were not fully facilitated. Students with visual, auditory, or kinesthetic learning received the same treatment without adjustments to learning strategies, so their understanding of the material may not have been optimal.

The TaRL approach principle prioritizes the fulfillment of individual learning needs. The TaRL approach applied in the experimental class allows students to learn by doing, thereby encouraging deeper understanding. Learning by doing can attract students' attention and improve their learning outcomes (Sophan *et al.*, 2018). Setyawati (2023) revealed that differentiated learning is effective in improving students' understanding through mapping their learning needs. The improvement in student learning outcomes is supported by the N-gain test results shown in **Figure 3**.

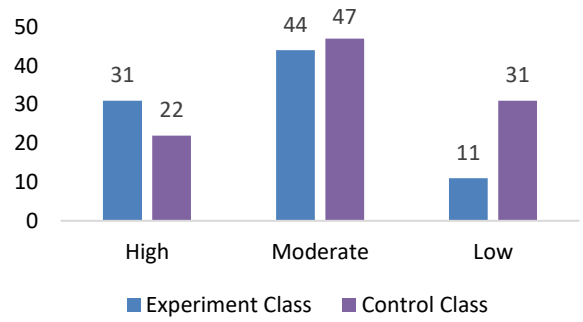

Figure 3. Percentage of Interpretation of N-Gain Test Results of Student Learning in the Control Class and Experimental Class

The results show the distribution of students based on criteria in N-Gain scores. In the experimental class, 31% of students were in the "high" category, while in the control class, 47% were in the "moderate" category, indicating that the PBL-TaRL model had an impact on improving student learning outcomes in the experimental class on the subject of the coordination system. Learning strategies tailored to students' learning styles can increase student engagement and improve students' academic abilities (Lestari *et al.*, 2024).

Table 6. Proportion of Student Learning Mastery Based on Cognitive Indicators (C1-C6)

Indicator	% Correct		Total Correct Answer	
	Experiment	Control	Experiment	Control
C1	100	100	59	58
C2	97	94	63	65
C3	97	100	83	101
C4	100	100	176	150
C5	100	94	132	94
C6	72	56	26	20
Total			539	488

The percentage of students who answered correctly on each indicator was analyzed based on the number of students who answered at least one question correctly on that indicator. The results showed that in the experimental class, indicators C1, C4, and C5 had the highest achievement rates, with all students achieving a percentage of 100%. In the control class, the highest achievement rates were on indicators C1, C3, and C4.

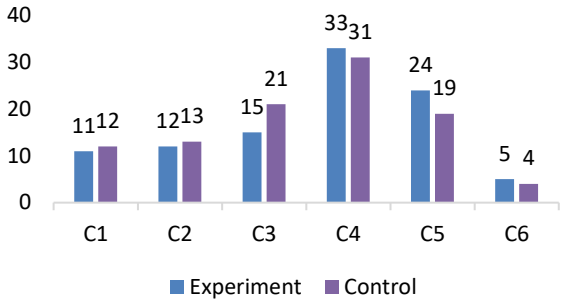

Figure 4. Percentage of Students in Achieving Each Aspect of Cognitive Indicators

Improvements in learning outcomes were also seen in the cognitive achievement levels of students. Based on the results of the cognitive indicator analysis, the highest proportions achieved in the control class were C3 at 21% and C4 at 31%. The achievement of cognitive indicators in the experimental class was in indicator C4, which was 33%, and C5, which was 24%, indicating progress in students' analytical and evaluative abilities. These results show that the cognitive achievement of students in the control class tended to be in the application and analysis abilities, while students in the experimental class reached the evaluation stage. The difference may occur because learning in the control class uses LKPD without differentiation of learning styles in the content material, so that students' understanding of the material is not facilitated. The results also show that the PBL-TaRL model not only facilitates students' low-level understanding but also encourages students' mastery of high-level thinking aspects, even though indicator C6 obtained the lowest percentage. The low achievement on the C6 cognitive indicator is because there was only one question representing that indicator, unlike the C4 and C5 indicators, which had seven and five questions, respectively. The imbalance in the number of questions is the result of selection based on validity tests, which affects the percentage of achievement between indicators. The results obtained in the experimental class still show a tendency toward higher-order thinking, particularly in the ability to analyze and evaluate. Nisa *et al.* (2025) revealed that the PBL-TaRL model encourages students to actively engage in learning, making it suitable for deepening students' critical thinking.

Table 7. Pretest and Posttest t-Test of the Coordination System

Independent sample T-test	Sig. (2-*tailed*)	Remarks
Coordination System Pretest	0,324	Not Significantly Different
Coordination System Posttest	0,046	Significantly Different

The posttest t-test results showed a significance value (2-tailed) of 0.046, which means that the value is < 0.05. These results indicate that there is a significant difference between the posttest results in the control class and the experimental class, so it can be concluded that the PBL learning model in the TaRL approach has a significant effect on student learning outcomes. Rahmawati & Gumiandari (2021) stated that students are better at receiving and processing information in the learning process delivered by teachers through adapting each student's learning style.

The results of this study have implications for learning practices in schools. The application of the PBL-TaRL model through differentiated learning based on students' learning styles can be an effective alternative strategy for improving collaboration skills and student learning outcomes, particularly in complex materials such as coordination systems. By actively engaging students in learning that aligns with their

individual learning styles, teachers can create a more meaningful and collaborative learning process and encourage a deeper understanding of concepts.

CONCLUSION

Based on the results of the study, it can be concluded that the application of the Problem-Based Learning (PBL) model with the Teaching at the Right Level (TaRL) approach has a positive effect on students' collaboration skills and learning outcomes in the subject of coordination systems. This is shown by the N-gain results and t-tests of collaboration skills and of students' learning outcomes. The PBL-TaRL model based on learning styles is considered effective as an innovation in learning strategies, making the learning of coordination systems more innovative, meaningful, enjoyable, and accommodating to students' learning needs.

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