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PROJECT-BASED COLLABORATIVE LEARNING ON STUDENT CONCEPT-APPLICATION WITH DIFFERENT PRIOR KNOWLEDGE

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Abstrak
Tujuan penelitian ini adalah untuk mengetahui pengaruh *Project-based Collaborative Learning* (PBCL), *Project-based Learning* (PjBL), dan pembelajaran konvensional terhadap kemampuan penerapan konsep peserta didik dalam pembelajaran biologi, dengan mempertimbangkan konsep pengetahuan awal, serta interaksi antara strategi pembelajaran dan pengetahuan awal yang dimiliki peserta didik. Penelitian ini dirancang dengan jenis quasi eksperimen menggunakan *pre-post-test non-equivalent control group*. Seratus peserta didik tingkat SMA berpartisipasi sebagai sampel penelitian. Observasi, tes, dan dokumentasi dilakukan sebagai teknik pengumpulan data. Data kemampuan penerapan konsep peserta didik secara teknis diperoleh dari tes. Selanjutnya, data dianalisis menggunakan ANCOVA. Hasil uji statistik menunjukkan strategi pembelajaran (PBCL, PjBL, dan konvensional) berpengaruh signifikan terhadap kemampuan peserta didik dalam menerapkan konsep biologi. Hasil pengetahuan awal peserta didik juga menunjukkan pengaruh signifikan terhadap kemampuan penerapan konsep peserta didik. Interaksi antara strategi pembelajaran dan pengetahuan awal peserta didik juga berpengaruh terhadap kemampuan penerapan konsepnya. Temuan ini menunjukkan bahwa PBCL secara signifikan berkontribusi pada pemahaman konsep dalam kehidupan peserta didik sehari-hari. Namun, disarankan agar penelitian selanjutnya membahas tentang topik lain baik di SD maupun SMP. Penelitian selanjutnya juga dapat berfokus pada pengukuran hasil belajar yang lebih tinggi dari aplikasi konsep, seperti analisis konsep, sintesa, evaluasi, *problem solving*, dan kemampuan keterampilan peserta didik lainnya.

Kata Kunci: Kemampuan Penerapan Konsep; *Project-Based Collaborative Learning*; Pengetahuan Awal.

Abstract
This research was determined the effect of Project-based Collaborative Learning (PBCL), Project-based Learning (PjBL), and conventional learning on students' concept application skills in learning biology, considering the prior knowledge, as well as the interaction between learning strategies and students' prior knowledge. This research was designed as a quasi-experiment using pre-post-test non-equivalent control group One hundred high school students participated as research samples. Observations, tests and documentation were conducted as data collection techniques. Data on students' concept application skills were technically obtained from tests. The data were analyzed using ANCOVA. The statistical test results showed that the learning strategies (PBCL, PjBL, and conventional) significantly affected students' ability to apply biological concepts. The students' prior knowledge results also showed a significant influence on students' ability to apply concepts. The interaction between learning strategies and students' prior knowledge also influences their ability to apply concepts. These findings indicate that PBCL significantly contributes to the concepts understanding in learners' daily lives. However, it is recommended that future research addresses other topics in both elementary and junior high schools. Further research can also focus on measuring higher learning outcomes from concept application, such as concept analysis, synthesis, evaluation, problem solving, and other students' skill abilities.

Keywords*: Concept-Application Ability, Project-Based Collaborative Learning, Prior Knowledge*

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INTRODUCTION

Benjamin S. Bloom proposed that a high degree of education can be applied to all learning levels in the cognitive domain (Yeo et al., 2022). According to Panis et al. (2023), the cognitive domains are behavioral focuses on intellectual elements, such as knowledge, problem-solving abilities, and thinking abilities ranging from Lower Order Thinking Skills (LOTS) to Higher Order Thinking Skills (HOTS). Three characteristics of HOTS are the capacity to analyze (C4), evaluate (C5), and create (C6), while three LOTS abilities are remembering (C1), understanding (C2), and applying (C3) based on the updated taxonomy by Bloom (Waite et al., 2020).

Concept-application ability is an integral part of students' cognitive domain of learning outcomes. (Adams, 2015) suggests that the students' concept-application ability means the ability in applying for ideas, knowledge, methods, formulas and theories in learning. The ability engages two important processes, among others; namely students are able to do and implement a procedure in certain circumstance (Anderson & Krathwohl, 2001). Das, et al., (2022) emphasizes that it is highly recommended that students of high school master this ability. High school students should be able to apply knowledge in a real context. In addition, the ability is on the third level cognitive process domain, after remembering (C1) and understanding (C2). This ability is one of the 21st century education purposes.

When high school students do concept application especially biology, it deals with their prior knowledge that they have gotten from junior high school. Binder, et al., (2019) suggest that in carrying out biology learning activity, teacher(s) should be able to integrate between students' knowledge and experience into the learning. Therefore, students' prior knowledge needs to be explored at the beginning of learning process, and then teacher develops students' concepts based on that prior knowledge. If the students can combine the knowledge they've known before with the new one, they can understand the concept better and help themselves to do the concept-application (Yeo et al., 2022).

Based on the observation, the students' learning results show that cognitive domain of high-school students' concept-application ability in Surakarta, Indonesia is about 41.06%, which means it is in a relatively low category. The observations were carried out five times in November to December 2022. The results shows that the applied learning strategy was conventional learning. It is a commonly applied strategy used by teacher(s) in classroom learning to convey information verbally. One of the conventional learning methods is lecturing (Efu, 2019). Lecturing method is a typical teacher-centered learning; it is insufficient to develop students' learning outcomes ability such as application skills.

The lack of concept-application ability negatively affects students' both short and long terms consequences. The short-term consequence concerns about students' learning outcome which is far from the learning target (Prakash & Litoriya, 2022). Human brain should be used for high order thinking such as applying the acquired concept, not only for low order thinking (memorizing).

Students' low application ability needs to be improved by implementing learning strategy namely Project-based Learning (PjBL) and collaborative approach. PjBL is a strategy which bridges knowledge and real life. This allows students to learn by applying their knowledge to cope with problems in their lives (Requies et al., 2018). As a result, it helps students develop the twenty-first century skills like communication, collaboration, and critical thinking to produce quality products in addition to providing content (Madouas et al., 2023). Additionally, PBL also sustains students' learning motivation with process-oriented and final results; it is expected to improve students' learning outcomes such as their concept application ability (Alvarez, 2023).

The collaboratively conducted PjBL is expected to be applicable to biology as it is a complex subject which has process and final-result oriented as well as is expected to develop collaboration. In addition, Seifert & Bar-Tal (2022) note that collaborative learning can foster students in working collaboratively to establish each other's understanding between fellow students. This integration provides students with benefits, if it is compared to projects carried out individually or within groups without sustaining structure.

Project-based Collaborative Learning (PBCL) is a typical strategy of learning that integrates PjBL with collaborative learning strategy (Bartolomé & Benítez, 2022). This learning is conducted by considering PjBL phase in the context of work groups through cooperative or collaborative approach. Sukmawati, et al., (2020) emphasize that when project-based learning is implemented by the teacher in a stand-alone way, students' ability to collaborate is reducing. Thus, collaborative learning is importantly required in carrying out tasks in project-based learning. Integrating PjBL with collaborative learning strategy helps students to gain their positive results. Many studies indicate that the positive results of using PBCL strategy certainly increase students' learning activity in addition to students' ability in working collaboratively (Marquez et al., 2023). Project-based Collaborative Learning potentially creates a learning environment which develops the twenty-first century knowledge and skills.

Project-based Collaborative Learning constitutes a syntax; which involve; begins with the Essential Question, Design a Project Plan, Makes a Schedule, Evaluates the Product, and Assesses the Experiences or Results (Alvarez, 2023). In the syntax, students are required to use all their senses, minds, and hearts to seek for knowledge. Students' direct involvement in establishing their own knowledge, designing and making projects that is applicated to human life contexts can encourage the development of students' concept-application ability (Burks, 2022).

In addition to teacher's applicated learning strategy, in learning biology, students' prior knowledge reflects a quite important role (Yeo et al., 2022). This is an implication of a correlation between one material to the others. It means that there is a correlation between students' prior knowledge and the new one that a teacher is delivering in the classroom. The prior knowledge is used by the teacher to determine the basic competencies that students need to know and become the starting point in teaching. Students' learning activity should foster their world sense, which is done by applying their understanding on the old to new experiences (Dukhan, 2021). In other words, each student should comprehend and master the old concept before learning new knowledge, bearing the old and new knowledge are interrelated.

It is very important to conduct a biology learning which focuses on investigating the differences of PBCL, PjBL and conventional learning as they are implemented towards students' concept application skills by considering students' prior knowledge and interaction between learning strategies and stage of students' prior knowledge towards their concept-application ability in biology learning.

METHOD

The research was quasi-experimental study which applied the pre and post-test for non-equivalent control group design. In this research, PBCL, PjBL and conventional learning strategies and prior knowledge (high and low) were independent variables, while the dependent variable was the students' concept-application ability. The quasi-experimental study design is presented in Table 1.

Table 1. Quasi-experimental study design

Pre-test	Group	Post-test
O_1	X_1P_1	O_2

O_1	X_1P_2	O_2
O_1	X_2P_1	O_2
O_1	X_2P_2	O_2
O_1	CP_1	O_2
O_1	CP_2	O_2

Description: X_1 = PBCL, X_2 = PjBL, C = conventional, P_1 = high prior knowledge, P_2 = low prior knowledge, O_1 = pre-test result, O_2 = post-test result

All students in senior high school's eleventh grade represented the study's population in Surakarta which engaged 150 students. 100 students were drawn from the population using cluster random sampling technique. The sample group was divided into three classes, students in grade XI A1 and XI A2 as the experimental classes and students in grade XI A3 and X1 A4 as the control class. In the experimental class of A1, PBCL strategy is applied, while PjBL strategy is implemented in the experimental class of A2. The learning process in the control class A3 and A4 is conventional strategy which is lecturing method.

The instrument of concept-application ability test which is valid can be used to obtain the data of concept-application ability. The data collection is technically carried out two times, pre-test and post-test on all three learning strategies. The data of concept application ability score were tested statistically using the ANCOVA test or covariance analysis of SPSS 2.3 program for Windows. Then, further test was carried out with the LSD (Least Significance Different) test at the actual level of 5%.

The research procedure was divided into three stages including the identification, implementation, and evaluation stages. The identification stage includes preliminary study by conducting a survey activity in one of the senior high schools in Surakarta. At the implementation stage, the researcher implement pre-test to students of both experimental classes and the control class. Then, some treatment tests are conducted by applying PBCL and PjBL strategies to the experimental classes and applying conventional strategy to the control class. After having given the treatment to both classified students with PBCL, PjBL and conventional strategies, the post-test was carried out. In the evaluation stage, further activity was processing the pre and post-test data and analyzing the results of data in addition to processing those obtained data.

The concept-application ability score, pre and post-test was adjusted to the range of 0 to 100. Then, normality and homogeneity tests were carried out as a condition for testing the hypotheses. Hypothesis testing was done with normal and homogeneous data distribution conditions. The Covariate analysis (ANCOVA) analytically is done to find out; (1) the differences of concept-application ability of the students implemented by three different learning strategies: PBCL, PBL and conventional models; (2) the differences of concept-application ability between low and high prior knowledge students; and (3) the differences of concept-application ability as a result of interactions between learning strategies and prior knowledge. If some differences were found, the post hoc least significant difference (LSD) test was conducted to determine if there are differences with statistical significance or not significance.

RESULTS

The data obtained from the test of students' concept-application ability were further analyzed using SPSS 23.0 for Windows. The test of normality using a single sample of the Kolmogorov-Smirnov test model and the test of homogeneity using the variance error equation were performed prior to the analysis. Table 2 below clearly illustrated the summary of the normality and homogeneity test.

Table 2. Normality and homogeneity tests for pre-test scores summary

Data Group	*Prior knowledge*	*Normality One Sample Kolmogorov Smirnov Test*				*Homogenity (Levene Test)*	
		Mean (Pre)	*Sig.*	*Mean (Post)*	*Sig.*	*Sig. (Pre)*	*Sig. (Post)*
PBCL	high	74.2222	0.200	87.1667	0.200	0.066	0.063
	low	73.5882	0.157	80.4118	0.057		
PjBL	high	75.9167	0.053	83.1667	0.200,		
	low	72.6522	0.059	79.3043	0.068		
Conventional	high	74.2353	0.076	81.2941	0.081		
	low	62.6154	0.105	67.8462	0.200		

The data are normally distributed, as shown in Table 2, and the data group exhibits a homogeneous variant (significance of normality and homogeneity>0.05). This preliminary examination can be used to further analyze the data using ANCOVA. The ANCOVA results of the concept-application ability based on learning strategies and prior knowledge illustrated in Table 3.

Table 3. ANCOVA test results summary

Source	*Type III (Sum of Squares)*	*df*	*Mean Square*	*F*	*Sig.*
Corrected strategy	7245.891	6	1207.649	27.529	0.000
Intercept	1104307.972	1	1104307.972	25173.014	0.000
Pretest	3018.645	1	3018.645	68.811	0.000
Startegy	1946.537	2	973.269	22.186	0.000
Prior Knowledge	2078.408	1	2078.408	47.378	0.000
Prior Knowledge * Strategy	809.183	2	404.592	9.223	0.000
Error	8466.664	193	43.869		
Total	1181119.000	200			
Corrected Total	15712.555	199			

According to Table 3, the ANCOVA test results on learning strategies, F = 22.186 had a significance value of 0.000 ($p < 0.05$), indicated that there was a significant difference in the students' ability to apply their knowledge among those who used the three different learning strategies. Additionally, LSD post hoc analysis was done for learning strategies to see if there were statistically significant differences. The LSD test results for learning strategies as elaborated in Table 4 below.

Table 4. The LSD test based on learning strategies results

Learning strategies	*Average Score*			*Notation*
	Initial	*Final*	*Difference*	
PBCL	73.9143	83.8857	9.9714	a
PjBL	73.7714	80.6286	6.8572	b
Conventional	69.2000	75.4667	6.2667	c

Based on the LSD test results in Table 4, there were a difference in the average score of the concept application ability based on the applied learning strategies. According to the notation, students achieved the highest score for concept application skills when taught using PBCL, and that differed significantly from other learning strategies. The concept-application ability of students taught using PjBL learning strategy achieved higher scores that were significantly different the group of students taught using conventional learning strategies. The concept-application ability score of the students who are taught using traditional methods is significantly lower than that of the other groups.

The ANCOVA prior knowledge results as illustrated in Table 3 shows that the significance level for the F value (47.378) was 0.000 ($p < 0.05$). This indicated that H_0 is rejected, and Ha is consequently accepted. Therefore, there is a difference in the application ability among students who have higher academic skills and students who have lower prior knowledge. Additionally, to

determine if there is any significant difference statistically, LSD is carried out to figure out the prior knowledge. The result is written in Table 5 below.

Table 5. The Comparison Between Concept-Application Ability Score and Prior Knowledge

Prior Knowledge	*Average Score*			*Notation*
	Initial	*Final*	*Difference*	
High	74.6596	84.0213	9.3617	a
Low	70.4906	76.8491	6.3585	b

The LSD test results in Table 5 showed a significant difference in the mean prior knowledge score. High prior knowledge students outperformed those with low prior knowledge students in terms of average score.

As illustrated in the Table 3, the ANCOVA analysis results on the interaction between learning strategy and prior knowledge, revealed that the F value = 9.223 with a significance value of 0.000 ($p<0.05$). This means that H_0 is rejected. Thus, there is a difference in students' application ability due to the occurring interaction between prior knowledge and learning strategies. The LSD test results regarding concept-application ability between the applied strategies and prior knowledge are elaborated in Table 6 below.

Table 6. The Application Ability Average Score Comparison in Term of Interaction Between Learning Strategies and Prior Knowledge

Learning Strategies	*Prior Knowledge*	*Average Score*			*Notation*
		Initial	*Final*	*Difference*	
PBCL	High	74.2222	87.1667	12.9445	a
	Low	73.5882	80.4118	6.8236	b
PjBL	High	75.9167	83.1667	7.2500	b
	Low	72.6522	79.3043	6.6521	b
Conventional	High	74.2353	81.2941	7.0588	b
	Low	62.6154	67.8462	5.2308	c

The LSD test results based on Table 6 had shown that students with learning prior knowledge by using the PBCL strategy have higher concept application capabilities than the other groups. Similarly, prior knowledge students below who learn by using PBCL strategies have higher concept application skills compared to other groups of early knowledgeable students.

DISCUSSION

This study results revealed that there were significant differences in score regarding the ability of concept-application for different learning strategies (see Table 4). Students taught using PBCL have higher application abilities than those taught using PjBL, and the lowest scores were achieved by student who were taught using conventional learning strategy. Conversely, students gain higher score when the teacher implemented PBCL strategy in their classroom. The findings of this study are consistent with those of earlier educational technology research, which demonstrate that using a project-based learning strategy coupled with collaborative learning improves students' cognitive abilities, including their capacity for concept-application. (Aifan, 2022; Khuluq et al., 2023).

The PBCL strategy that was implemented to the experimental class significantly contributes to increase students' concept-application ability score. In line with the previous theories, real experience through production process as a means of biology learning also contributes to expand students' academic knowledge (Wang et al., 2023). Thus, it increases students' concept-application ability. According to Rupavijetra, et al., (2022) PBCL approach is one of the contextual learning strategies that characteristically consists of project work, problem-based,

students' context-oriented learning, and has collaborative interdependent learning groups which enables students to learn from each other.

Implementing PBCL, according to Krajcik, et al., (2023), may foster students' involvement in the process of discovering their own thinking abilities. Students have the chance to produce and discuss concepts or ideas, solve problems, make strategies, exchange ideas, seek to resolve the encountering problems, create projects, and develop creativity through project learning strategy. This contrast with conventional learning strategy, which encourages individual learning and a more passive approach to the teacher's delivery of information, listening to the teacher, or merely working on the student's worksheet (Efu, 2019).

The significant contribution of PBCL strategy lies in its function to improve students' concept-application abilities, in addition to use PBCL learning syntax, which is in line with the nature of empowering students' concept application abilities. Alvarez (2023) added that designing a project is the basis of PBCL. Designing a project requires students' efforts, either individually or in groups, to apply knowledge of concept that they have mastered with or without teachers' guidance. Project work activity begins with identifying problems, reviewing literature and sources of learning, formulating problems, designing products, conducting experiments, producing or making things to product evaluation stage, all of which encourage students' creative skills which can affect their competencies (Hujjatusnaini et al., 2022). In addition, implemented PBCL encourages students to actively involve themselves in classroom learning activities (Vani et al., 2023). It provides students with opportunities to integrate the obtained theories, solve problems, work collaboratively, provide great opportunities for students in making decisions to accomplish project work, help to foster a joyful learning circumstance, help them gain an in-depth material concept, also support them to apply the high-order thinking (Aprianto et al., 2023; Khoiri et al., 2023).

Project-based Learning strategy combined with collaborative strategy take students of senior high school whose age 15 to 18 years old as research subject. According to Piaget, the formal operational stage is where students are at in their cognitive development. Students can think abstractly, logically, and analytically at this stage, as well as seek solutions to problems. (Requies et al., 2018). In the learning process implemented PBCL strategy, there are several skills that students believe to have developing contributions, which is the ability to work collaboratively in groups; the use of various sources of information to complete certain tasks; the ability to interpret, apply, and express the information into writing; the ability to apply material related to the digestive system and human's anatomy movement system in daily life; and the ability to manage and develop self-potential ability. Having acquired these skills, students' learning outcomes can increase.

PBCL strategy is compatible with biology learning in senior high school. This is due to the application of knowledge in biology as a learning subject. Thus, biology is not only about mastering concepts in the form of a collection of principles or facts but also about applying them into real life. Students can learn about themselves and their environment while studying biology in high school, and they can use what they learn to some extent in their daily life. Madouas, et al., (2023) emphasizes that PBCL provides opportunities for students to apply the acquired knowledge into their real lives.

The project-based learning strategy and collaborative learning strategy combination in biology learning contributes greatly to improve students' concept-application ability. This is because integrating collaborative strategies at each stage begin with the stage of designing the project, creating, and evaluating the work or project results to make it easier for students to

understand and manage learning material, also apply it effectively and systematically. Collaborative learning is an ideal learning strategy to practice concept-application ability. This is because collaborative strategies create a student-centered, contextual, integrated and collaborative learning environment. Based on this assumption, learning to use collaborative strategy is expected to provide students with opportunity to be the participate actively in the learning process, maximize collaboration between students, and contribute to enrich students' experience (Vandeyar & Mohale, 2022).

The findings regarding the use of the PBCL strategy in this study are in line with educational technology research that has been conducted previously (Alibraheim & El-Sayed, 2021; David, 2018; Rofik et al., 2022). According to Alvarez (2023), PBCL increases students' learning activeness which brings a fun learning circumstance. By integrating project-based learning strategy and cooperative learning, students benefit from the learning. Therefore, this strategy emphasizes the completeness of students learning activities through group collaboration, awarding, and in addition to teachers' collaborative role.

PBCL leads students to be active and proud of themselves for having more intellectual challenges. PBCL strategy encourages students to actively participate in learning, cooperative with the groups, exchange opinions in solving problems, increase self-confidence, increase motivation to learn, train students to appreciate differences. To do so, the peer roles in a group encourage students' enthusiasm for learning and reduce individual dominance.

In addition to learning strategies, prior knowledge contributes to differences in students' concept-application ability. The LSD test results shows the interaction between learning strategy and prior knowledge towards students' application ability as illustrated in Table 6. Based on the LSD test results, students with low prior knowledge which get PBCL as the treatment shows the highest difference score for the concept-application ability than other groups of students. This study indicates that there are differences in the ability of concept-application between students who have low with high prior knowledge. The results of the high concept-application ability achievement to students with low initial knowledge with PBCL strategy, in this study, indicates that the PBCL strategy is an effective method in improving concept-application ability of students with low prior knowledge. Irwan, et al., (2023) suggest that PBCL strategy encourages students' learning atmosphere to become active and alive. Project activities enable students to create a more real learning situation. It is perceived as contributing to increasing various skills and sharing ideas while socializing in discussion groups, consequently students with low prior knowledge are also involved in the learning process.

According to Wang, et al., (2023) a learning strategy which train students to participate in collaborative learning contribute to the improvement of low prior knowledge students. The implementation of learning groups with heterogeneous members will encourage students' active engagement to solve the arising problems during a discussion activity; this reduces the gap between high and low prior knowledge students. As a result, low prior knowledge students can develop a concept-application more effective.

CONCLUSION AND RECOMMENDATION

This study's findings can be used to draw a conclusion that answer research problems, such as: (1) there are differences in students' ability of concept-application between the three different learning strategies implemented: PBCL, PjBL and conventional models. Students tested using PBCL show the highest application ability; (2) there are differences in the concept-application abilities between high and low prior knowledge students; and (3) there are differences in the concept-application ability due to the occurring interactions between learning strategies and students' prior knowledge.

Similarly, low prior knowledge students are found to have increased their concept-application ability after being taught with PBCL strategy. This shows that PBCL is an effective strategy to biology learning subject. The researchers would like to recommend teacher to use PBCL, particularly in biology learning to improve students' concept-application ability. Students need to train hard for the concept-application ability as it is quite important for them in term of handling the challenge in twenty first century. This study can be basis for further study on biology subject or other learning subjects at elementary school, junior high school, and other level of education. Future study may also focus on other skill abilities.

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