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Improving Students' Collaboration Skills Through Project-Based Learning on Environmental Change Material

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Abstract: Collaboration skills are one of the six life skills that are important to have in the 21st century, enabling students to work together, exchange ideas, and respect other people's opinions. This research aims to improve collaboration skills through Project-Based Learning (PjBL) on environmental change material. The research method used was a quasi-experiment with a nonequivalent pretest-posttest control-group design. The sample for this research is high school students who are studying Environmental Change material. Collaboration skills questionnaires and observations of learning implementation were used as research instruments. The data analysis used was the Independent Sample T-Test and the N-Gain test. The results of the Independent Sample T-Test show that the average posttest score for the control and experimental classes is significantly different by 0.000. The collaboration skills of experimental class students obtained a mean of 86.39 in the very good category, and the N-Gain test result was 0.465 in the moderate category. This increase is supported by the results of learning implementation, with an average score of 89.89% in the very good category. This research implies that it can provide practical guidance for teachers interested in integrating PjBL into learning.

Keywords: Collaboration skills, Project-Based Learning (PjBL), Environmental change

Introduction

Many aspects of life are fundamentally changing in the 21st century. Everyone must have good cognitive abilities and social dispositions (Ilma et al., 2020). The new orientation of education seeks to make institutions like life skills educational institutions. This effort aims to achieve competency so that the learning process is authentically and contextual (Fajra et al., 2020). Students must also master 21st-century skills known as 6C, including character, citizenship, creativity, critical thinking, collaboration, and communication (Artama et al., 2023).

One of the six life skills that must be mastered in the 21st century is collaboration skills, which are very important for students to consider as they enter the workforce in the twenty-first century (Hairida & Kartono, 2021). Collaboration is considered a skill that is a general need in today's world of work and encourages

students to engage in peer interaction throughout class activities. Students who work together will be able to respect one another's differences and put the group's welfare first (Putri et al., 2021).

However, the research results of Hidayat et al. (2020) in one high school in Bandung, Indonesia show that students' collaboration skills are not optimal. This is evident throughout the learning process, as some students play on their phones, discuss topics unrelated to the course subject with their friends, and are not yet motivated to learn. Collaboration skills, especially the ability to communicate and motivate each other, are still problematic, so students have less motivation in teamwork (Gasonpan & Temdee, 2021; Ralph, 2015). Many students still find it difficult to tolerate differing viewpoints and not accountable to their group, so collaboration skills are not fully utilized (Ilma et al., 2020; Putri et al., 2021).

Collaboration skills have not been maximized because the learning that has occurred thus far has mainly been on cognitive learning outcomes (Ilma et al., 2020). Goals related to soft skills, such as collaboration skills, are difficult to achieve because teachers still carry out traditional or teacher-centered learning, where teachers dominate the teaching and learning process (Artama et al., 2023; Guo et al., 2020). Teacher-centered learning does not increase but reduces students' learning abilities (Khoiri et al., 2023). This makes it difficult for students to fully engage in learning (Guo et al., 2020).

Thus, learning strategies are needed to develop collaboration skills, which are important skills that must be possessed in the 21st century. The teacher's role in learning is the key to activating student learning activities (Artama et al., 2023). In order to inspire and motivate students to actively engage in the teaching and learning process, teachers should think about using effective learning strategies (Gunawan et al., 2017; Khoiri et al., 2023; Rahmawati & Haryani, 2015). Teachers can plan learning strategies by implementing appropriate learning models to improve students' collaboration skills.

Project-Based Learning (PjBL) is one strategy that may be applied. The project itself is PjBL's primary feature. A product or a student's performance may be the project's result. PjBL allows students to explore new things and participate actively in learning. Teachers become facilitators when students face difficulties and need direction (Artama et al., 2023; Khoiri et al., 2023). PjBL is also carried out to deepen the knowledge and skills obtained by creating a work or project related to student competencies (Fajra et al., 2020).

The research results of Putri et al. (2021) show that PjBL can increase the score of students' collaboration skills in the experimental class by 15.37%, with work management showing the greatest improvement. Students actively participate in overseeing the execution of projects. The completion of the project proves this according to the specified time. Khoiri et al. (2023) also stated that the average score for collaboration skills in the experimental class that implemented PjBL was 45.85, while the control class that used conventional learning was 19.97.

In studying biology, especially in high school, students often find it difficult to master biology (Sukmawati et al., 2019). This is because biology subjects have complex materials, objects that are not directly visible and intangible, and many scientific terms (Cimer, 2012). Another problem that arises from learning biology is that students find it difficult to apply the knowledge gained in real life (Chavan & Patankar, 2018; Sukmawati et al., 2019).

One of the social issues in real life that is increasingly complex and worrying today is the issue of Environmental Change. In Indonesia, several environmental problems that are quite disturbing people's lives include waste pollution (Ratini. et al., 2018), climate change due to human activities and the industrial sector (Nafisah et al., 2022), and solid waste management (Aliman et al., 2020). The accumulation of rubbish in public places and the environment around people's homes is becoming an increasingly big problem. Waste that is allowed to accumulate and not managed negatively impacts the surrounding land and water sources (Shailaja et al., 2016). By implementing PjBL on Environmental Change material, students can understand that the big impact of environmental change is not just the responsibility of one person or one country but requires massive collaborative action from all parties (Saribas, 2015). Thus, implementing PjBL on Environmental Change material is an effort to improve students' collaboration skills.

Method

This study used a quasi-experiment research method with a nonequivalent pretest-posttest control-group design (Cresswel, 2014). Two treatment groups, an experimental group and a control group, are used in this design.

The experimental group applied PjBL, while the control group applied learning that teachers usually apply when teaching Environmental Change material, namely Cooperative learning. An initial test (pretest) and final test (posttest) of collaboration skills were given to each group.

The population of this research is all class X students in one of the high schools in West Bandung Regency, Indonesia. The research sample included two classes, namely control and experimental classes, each class consisting of 36 students. The sampling technique was carried out using purposive sampling which was based on the characteristics of a non-homogeneous population and certain objectives. The sample criteria selected were students who were studying Environmental Change material.

The instruments used were collaboration questionnaires and learning implementation observation sheets. The collaboration skills questionnaire adapted from Ofstedal and Dahlberg (2009) consists of 22 statements measuring five indicators: contribution, participation, preparation, problem-solving, and reflection. A Likert scale was used to assess the questionnaire: one was for strongly disagreeing, two was for disagreeing, three was for agreeing, and four was for strongly agreeing. The scores obtained by students were then converted into a scale of 100 and categorized based on the guidelines provided by Hidayati (2019) in Table 1.

Table 1. Categories of student collaboration skills

Student Values	Categories
80 – 100	Very good
60 – 79	Good
40 - 59	Enough
20 - 39	Not enough
0 - 19	Very less

The learning implementation observation sheet is used to see how implementing PjBL improves collaboration skills. The observation sheet was modified from the PjBL stages based on Syarif (2017), including: 1. Start with the essential question, 2) Design a plan for the project, 3) Create a schedule, 4) Monitor the students and the progress of the project, 5) Assess the outcome, and 6) Evaluate the experience. The questionnaire was measured using a Likert scale: not done, score 1; done but not well, score 2; done quite well, score 3; done well, score 4; and done very well, score 5. The scores were then converted into a scale of 100 and categorized based on guidelines provided by Ekantini & Wilujeng (2018) in Table 2.

Table 2. Percentages of learning implementation

Average Percentages (%)	Categories
80 – 100	Very good
60 – 79	Good
40 – 59	Enough
20 – 39	Not enough
0 – 19	Very less

Collaboration skills data analysis includes prerequisite, mean, and N-Gain tests, which are analyzed using SPSS software. The Shapiro-Wilk test for normality and Levene's test for homogeneity were the two prerequisite tests used. The average test used is the Independent Sample T-Test. The increase in students' collaboration skills scores was analyzed using the N-Gain test, which was categorized into three categories, namely: high ((g) $\geq$ 0.70); moderate ($0.30 \leq (g) < 0.70$), and low ((g) < 0.30) (Hake, 1999).

Results and Discussion

The results and discussion that will be explained include 1) Achievement of student collaboration skills through PjBL, 2) Achievement of student collaboration skills through PjBL in each indicator, and 3) Implementation of PjBL learning in experimental class.

Achievement of Student Collaboration Skills Through PjBL

The achievement of collaboration skills can be determined by looking at each student's pretest and posttest scores after completing the collaboration skills questionnaire. The results of the collaboration skills

questionnaire were analyzed using statistical tests, including the normality test, homogeneity test, mean test, and N-Gain test. The statistical test results of students' collaboration skills can be seen in Table 3.

Table 3. Statistical test results of student collaboration skills

Data Type		Pretest		Posttest	
Class		Control	Experimental	Control	Experimental
N		36	36	36	36
Mean of Collaboration Skills		61.64	62.71	73.56	86.39
Categories of Mean		Good	Good	Good	Very good
Normality Test	Significance	0.318	0.323	0.982	0.238
	Interpretation	Normal	Normal	Normal	Normal
Homogeneity	Significance	0.928		0.276	
Test	Interpretation	Homogen		Homogen	
Independent	Significance	0.193		0.000	
Sample T-Test	Interpretation	Not significantly different		Significantly different	

The data in Table 3. shows that all pretest and posttest data in the control and experimental classes are normal and homogeneous data, so the statistical test used to determine the mean difference between the two is the Independent Sample T-Test. According to the results of the Independent Sample T-Test on the pretest, the experimental class received an average score of 62.71 in the good category. In contrast, the control class received an average score of 61.64 in the same category. This value is consistent with the Independent Sample T-Test findings, which indicate no significant difference ($p = 0.193$).

Before treatment, the average score of students' collaboration skills in the control and experimental classes was not much different. The lower difference in average scores before treatment is due to the relatively similar abilities between the two classes. This is known based on information from the biology subject teacher who teaches in both classes. Apart from that, learning is often carried out using the lecture method, and students are given practice questions to work on individually. Learning using the lecture method and practice questions does not allow students to discuss and interact with each other. Sholahuddin et al. (2021) also stated that learning in Indonesian schools begins with theoretical explanations, accompanied by examples given by the teacher, and ends with students completing practice questions.

The learning model applied generally only aims to enable students to understand concepts and does not support collaborative activities between students. Biology learning practices still predominantly apply conventional learning patterns that are more teacher-oriented, and this reality continues today (Pratama et al., 2018; Safitri et al., 2018). Teacher-centered learning does not increase but reduces students' learning abilities (Khoiri et al., 2023). This makes it difficult for students to fully engage in learning, resulting in a shallow understanding of science (Guo et al., 2020).

Meanwhile, the experimental class received an average of 86.39 in the very good category on the posttest, whereas the control class received an average of 73.56 in the good category. The Independent Sample T-Test findings, which indicate a significant difference between the two with a significance of 0.000, are consistent with this number. Table 3's data demonstrates that the average scores of the experimental and control classes differed from the pretest to the posttest. The experimental class saw a difference in value of 23.68, while the control class saw a difference of 11.92. Thus, the control class has the same initial and final collaboration skills categories, namely the good category. In contrast, the experimental class has different initial and final collaboration skills categories, namely the good to very good categories.

In contrast to the final learning outcomes, collaboration skills between the control and experimental classes differed significantly. The experimental class that implemented PjBL was superior to the control class that applied Cooperative learning. The high average posttest score for collaboration skills in the experimental class is because the PjBL stage facilitates and improves students' collaboration skills. In PjBL, each group is assigned to create a project so that each student can discuss, exchange ideas, and collaborate with fellow students. Hidayat et al. (2020) explained that students have demonstrated collaborative skills when they share and discuss their assignments.

The stages of creating a waste management project in the experimental class are collaborative activities carried out by students. The success of each group in creating a project is in line with finding the root of the problem during discussions. Problem discovery can improve collaboration skills because students can solve problems together. Working on projects can also improve students' communication skills through discussion,

implementation, and project presentation activities (Triana et al., 2020). The average N-Gain value shows the magnitude of the increase in collaboration skills in the control and experimental classes. The average N-Gain results can be seen in Table 4.

Table 4. Average student N-Gain value

Classes	Averages of N-Gain	Categories
Control	0.226	Low
Experimental	0.465	Moderate

The data in Table 4. shows that the average N-Gain value in the control class is in the low category with an average of 0.226, while the experimental class is in the moderate category with an average of 0.465. The greater increase in the average score in the experimental class shows that implementing PjBL in the experimental class can improve students' collaboration skills. PjBL provides learning opportunities for students to work in teams, plan, organize, negotiate, and convert thoughts and ideas into real work that is projected experimentally (Rais et al., 2021). The project work allowed students to work together and fully contribute to their group project. When friends ask questions, most students provide suggestions and try to answer questions from struggling friends. Gasonpan & Temdee (2014) explained that the PjBL learning process can improve collaboration skills and is important for future work. Thus, teachers are expected to continue to strive to develop students' collaboration skills by implementing collaborative learning.

Achievement of Student Collaboration Skills through PjBL in each Indicator

The collaboration skills measured in this research were adapted from Ofstedal & Dahlberg (2009). The indicators assessed include five indicators, namely contribution, participation, preparation, problem-solving, and reflection. The average pretest and posttest scores for each indicator of collaboration skills in the control class can be seen in Table 5.

Table 5. Average pretest and posttest scores for each collaboration skills ındicator in the control class

No.	Collaboration	Control Class				
	Skills Indicators	Pretest	Categories	Posttest	Categories	Enhancement
1.	Contribution	54.4	Enough	77.08	Good	22.68
2.	Participation	59.75	Enough	75.41	Good	15.66
3.	Preparation	63.75	Good	71.93	Good	8.18
4.	Problem-solving	63.1	Good	72.14	Good	9.04
5.	Reflection	63.1	Good	69.64	Good	6.54

The data in Table 5. shows that the indicator that obtained the highest posttest score in the control class was the contribution indicator of 77.08, with the highest increase of 22.68. The high increase in contribution indicators is due to one of the stages of Cooperative learning, namely group activities, which can facilitate an increase in contribution indicators. At this stage, each student works on a group worksheet, allowing students to share information when completing the student worksheet. Students are motivated to contribute during group work to complete the task optimally (Sari et al., 2017). Each group was also able to divide tasks equally among members. Ilma et al. (2020) explained that a balanced distribution of tasks in groups positively affects the quality of students' work.

According to the findings of an earlier study, Hairida and Kartono (2021) have determined that the group's contribution indicator, which stands at 72.57%, is in the high category. Every student contributes by offering ideas during class on how to finish group projects, and they are motivated to work hard to meet the group's objectives. Suppose group members are unable to cooperate. In that case, project work will not be effective because cooperation correlates with an individual's capacity to cooperate to accomplish a shared objective (Dewi. et al., 2020). Rahmawati et al. (2019) stated that student contributions can be trained through discussion because each student can share ideas, suggestions, or solutions.

The indicator that obtained the lowest posttest score was the reflection indicator of 69.64, with the lowest increase of 6.54. The low increase in reflection indicators is due to the Cooperative learning stage not facilitating an increase in these indicators. Control class students do not carry out reflection in learning, so students do not know their strengths, weaknesses, or things that need to be improved in the future. Meanwhile, reflection activities are very important for improvement, so performance is expected to increase in the future

(Hidayati, 2019). The collaboration skills achievements for each indicator in the experimental class can be seen in Table 6.

Table 6. Average pretest and posttest score for each collaboration skills indicator in the experimental class

No.	Collaboration Skills Indicators	Experimental Class				
		Pretest	Categories	Posttest	Categories	Enhancement
1.	Contribution	59.31	Enough	89.20	Very good	29.89
2.	Participation	60.88	Good	88.82	Very good	27.94
3.	Preparation	56.33	Enough	89.24	Very good	32.91
4.	Problem-solving	65.03	Good	85.24	Very good	20.21
5.	Reflection	65.20	Good	83.75	Very good	18.55

The data in Table 6. shows that the indicator that obtained the highest posttest score in the experimental class was the preparation indicator of 89.24, with the highest increase of 32.91. The high increase in preparation indicators was due to the PjBL stages, such as Design a plan for the project and Create a schedule, which facilitate an increase in preparation indicators. At the stage, students are assigned and directed to prepare the group's needs. These needs include preparing the necessary tools and materials, how to work on the project, and the schedules and deadlines for completing the project.

Before working on the project, each group is also assigned to present the project plan, project work design, and project implementation schedule. This process helps students correct any existing deficiencies, and each group is well-prepared to work on the project. Rahmawati et al. (2019) stated that good preparation will produce a good project.

Careful planning is necessary to implement a successful project (Habók & Nagy, 2016). Students are also responsible for the projects they work on. Responsibility for completing projects makes students focus on working on projects so they can be done on time and according to the provisions (Hairida et al., 2021). On the other hand, if only a few group members are active, they cannot produce productive work (Ilma et al., 2020).

The indicator that obtained the lowest posttest score was the reflection indicator of 83.75, with the lowest increase of 18.55. The low increase in reflection indicators is because the PjBL stages, such as Evaluate the experience, have not been optimal in facilitating an increase in reflection indicators. At the experience evaluation stage, students evaluate the projects they are working on. This stage also requires students to express feelings and experiences while working on the project. Both activities allow students to identify strengths and weaknesses, think about things that need improvement, and evaluate what worked and what did not during the project work process. However, these activities have not been carried out optimally, one of which is due to limited biology learning time.

Habók & Nagy (2016) revealed that measuring self-evaluation skills is important in PjBL. Self-evaluation has become an important skill in the 21st century for lifelong learning in a knowledge-based society, so the evaluation stage of learning and social skills in PjBL is very necessary for students. Involving students in the evaluation process is beneficial because it involves active participation, not just passively receiving information (Habók & Nagy, 2016).

Implementation of PjBL Learning in Experimental Class

The implementation of PjBL can be seen by looking at the average percentage at each meeting. The results of implementing PjBL in the experimental class can be seen in Table 7. The data in Table 7. shows that the average percentage of PjBL implementation varies at each stage. The stage that received the highest average percentage was the project assignment stage (third meeting) at 92% in the very good category. The high average percentage at the project assignment stage is because students are enthusiastic about working on projects with their groups, so the project work process runs well. In addition, students play an active role in groups and support each other when working on waste management projects. This activity follows the research results of Rais et al. (2021), which explain that PjBL can encourage each group to work on projects enthusiastically and that students enjoy learning developed based on PjBL.

The stage that obtained the lowest average percentage was start with the essential question (first meeting) at 88.15% in the very good category. Rais et al. (2021) stated that when students determine basic questions, they learn to collect information from various sources and select and process it according to the context presented.

Focus questions also allow students to explore in depth (Habók & Nagy, 2016). However, the low average percentage at the stage of determining basic questions is because some students still have difficulty determining one root problem based on several problems that have been identified. Apart from that, students also still have difficulty stating the reasons for choosing the root of the problem.

Table 7. Implementation of PjBL in the experimental class

No.	The Meeting - …. (PjBL Stages)	Observer Value (%)			Average Implementability (%)	Category
		Observer 1	Observer 2	Observer 3		
1.	1st Meeting (Start with the essential question)	86.67	88.89	88.89	88.15	Very good
2.	2nd Meeting (Design a plan for the project and Create a schedule)	88.33	91.67	90	90	Very good
3.	3rd Meeting (Project assignment)	90	92	94	92	Very good
4.	4th Meeting (Monitor the students and the progress of the project)	88	90.67	90.67	89.78	Very good
5.	5th Meeting (Assess the outcome and Evaluate the experience)	87.14	90	91.43	89.52	Very good
Overall Average					89.89	Very good

Thus, the PjBL learning stages can help students improve their collaboration skills. This is in line with Ilma et al. (2020) who claim that for students to acquire collaboration abilities, they need to study in a way that can help them engage with one another, collaborate to solve issues in groups, and share and accept responsibility. Collaborative learning is in-depth and can develop students' critical thinking, creativity, collaboration, and communication skills (Artama et al., 2023; Bertucci et al., 2010). Through investigation and project work, students may demonstrate their talents and ideas in this learning environment (Artama et al., 2023). Students with collaboration abilities can work well in groups and recognize each team member's contribution according to their assigned roles (Rais et al., 2021). Collaboration is important for learning, but it is also critical for daily problem-solving (Ilma et al., 2020).

Conclusion

The study's findings showed that PjBL was effective at helping experimental class students become improved collaborators on all indicators. Preparation was the indicator in the experimental class that increased the most, at 32.91, whereas the control class's contribution was 22.68. The experimental class's N-Gain analysis resulted in a value of 0.465, falling into the moderate category, whereas the control class's N-Gain value was 0.226, falling into the low category. The experimental class's learning observations provided an average percentage of 89.89% in the very good category, which is consistent with this outcome.

Recommendations

Recommendations that can be given are that it should be implemented over a longer period of time so that the data obtained on student collaboration skills is more comprehensive. Apart from that, it is necessary to integrate technology in PjBL according to current developments.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

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