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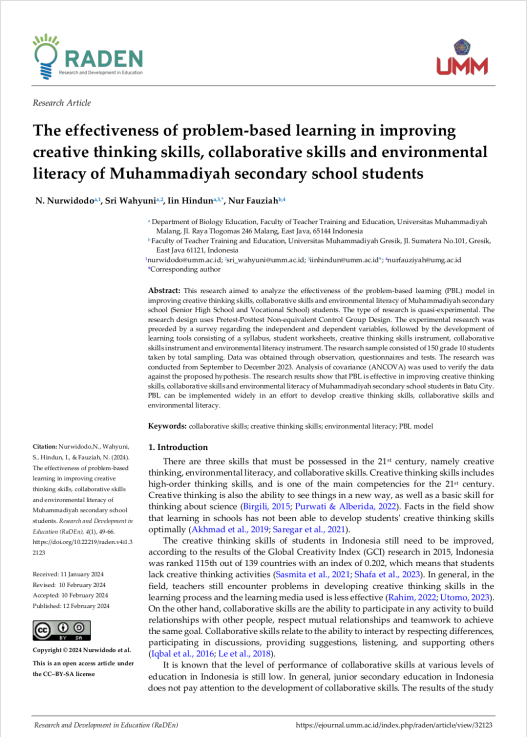

RADEN Research and Development in Education

UMM

Research Article

The effectiveness of problem-based learning in improving creative thinking skills, collaborative skills and environmental literacy of Muhammadiyah secondary school students

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Abstract: This research aimed to analyze the effectiveness of the problem-based learning (PBL) model in improving creative thinking skills, collaborative skills and environmental literacy of Muhammadiyah secondary school (Senior High School and Vocational School) students. The type of research is quasi-experimental. The research design uses Pretest-Posttest Non-equivalent Control Group Design. The experimental research was preceded by a survey regarding the independent and dependent variables, followed by the development of learning tools consisting of a syllabus, student worksheets, creative thinking skills instrument, collaborative skills instrument and environmental literacy instrument. The research sample consisted of 150 grade 10 students taken by total sampling. Data was obtained through observation, questionnaires and tests. The research was conducted from September to December 2023. Analysis of covariance (ANCOVA) was used to verify the data against the proposed hypothesis. The research results show that PBL is effective in improving creative thinking skills, collaborative skills and environmental literacy of Muhammadiyah secondary school students in Batu City. PBL can be implemented widely in an effort to develop creative thinking skills, collaborative skills and environmental literacy.

Keywords: collaborative skills; creative thinking skills; environmental literacy; PBL model

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There are three skills that must be possessed in the 21st century, namely creative thinking, environmental literacy, and collaborative skills. Creative thinking skills includes high-order thinking skills, and is one of the main competencies for the 21st century. Creative thinking is also the ability to see things in a new way, as well as a basic skill for thinking about science (Birgili, 2015; Purwati & Alberida, 2022). Facts in the field show that learning in schools has not been able to develop students' creative thinking skills optimally (Akhmad et al., 2019; Saregar et al., 2021).

The creative thinking skills of students in Indonesia still need to be improved, according to the results of the Global Creativity Index (GCI) research in 2015, Indonesia was ranked 115th out of 139 countries with an index of 0.202, which means that students lack creative thinking activities (Sasmita et al., 2021; Shafa et al., 2023). In general, in the field, teachers still encounter problems in developing creative thinking skills in the learning process and the learning media used is less effective (Rahim, 2022; Utomo, 2023). On the other hand, collaborative skills are the ability to participate in any activity to build relationships with other people, respect mutual relationships and teamwork to achieve the same goal. Collaborative skills relate to the ability to interact by respecting differences, participating in discussions, providing suggestions, listening, and supporting others (Iqbal et al., 2016; Le et al., 2018).

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It is known that the level of performance of collaborative skills at various levels of education in Indonesia is still low. In general, junior secondary education in Indonesia does not pay attention to the development of collaborative skills. The results of the study

state that the spread of gadgets and PlayStations over the last decade has encouraged people to have introverted, antisocial behavior and have difficulty interacting with the real world. This situation contributes to the low level of student collaborative skills in high school. In one study with the subject of biology students at Riau Islamic University, it was stated that students' collaborative skills generally showed at a sufficient level, which means they were not able to collaborate well (Nurwidodo et al., 2023).

Meanwhile, environmental literacy is a person's understanding of everything related to the environment, including knowing environmental problems, providing solutions and overcoming them. Environmental literacy is focused on knowledge (knowing), maintenance (caring), and authority/ability (competence) (Kuswendi & Arga, 2020; Miftahuddin et al., 2023). Environmental literacy is defined as "the ability to perceive and interpret the relative health of environmental systems and take appropriate action to maintain, restore, or improve the health of environmental systems (Erdoğan et al., 2009; Karimzadegan & Meiboudia, 2012). Based on the results of a study on environmental care behavior from the Ministry of the Environment in 2012, the Environmental Concern Change Index value for the 12 provinces surveyed was only around 0.57 percent (low category). This indicates that environmental care behavior, which is one component of environmental literacy, is still low among most people in Indonesia.

Learning is the right medium for developing creative thinking skills, collaborative skills and environmental literacy. Many learning experts promote the implementation of problem-based learning (PBL). PBL is a learning model that uses constructivist principles. In PBL, students participate actively in learning, where students are required to work collaboratively to solve problems, then discuss and reflect on what they have learned. PBL has several characteristics, namely (a) providing students with opportunities to explore, make judgments, interpret and synthesize information in a meaningful way; (b) allows students to investigate phenomena, facts or problems in a more real and meaningful way; and (c) present various ways for students to demonstrate their knowledge by providing many alternative answers, and not just one correct answer (Dong et al., 2021; Lenkauskaitė et al., 2021; Sukackė et al., 2022; Zhu & Zhang, 2023).

Various studies have been conducted in the context of PBL. Research focused on student's reading comprehension in English (Aulia et al., 2023), improving higher order thinking skills and character (Sulistiyani et al., 2022; Sutika et al., 2023), students' scientific attitude (Wulandari et al., 2021), students' 21st century skills (Rahman et al., 2023), student's mathematic ability (Ajinegara & Nuriadin, 2022), students' academic achievement (Bardel & Mahmoodi, 2020), critical thinking skills (Emiliasari et al., 2019; Fita et al., 2021; Masruro et al., 2021; Maulidiya & Nurlaelah, 2019; Setiawan & Islami, 2020; Shamdas, 2023; Widyatiningtyas et al., 2015), and science process skills and student learning outcomes (Pradasti et al., 2019). There is also focused PBL research pada physics learning (Reni Tania et al., 2020), problem-solving ability and self-confidence (Hendriana et al., 2018), students problem solving skills (Indrawsari & Rahmat, 2022; Yanto et al., 2021), facilitating sociology learning in the digital era (Andita Yuningtyas, 2023), Self-efficacy (M. Handayani & Louise, 2019), mathematical connection capability and learning outcomes (Mahendra et al., 2023), and economic learning outcomes of students (Lubis et al., 2022). There is research that focuses on aspects creative thinking skills, problem-solving skills, and learning outcome (Khoiriyah & Husamah, 2018). In the context of Malang, there are three studies that focus on Muhammadiyah, namely SD Muhammadiyah 8 KH Mansur, Malang City (Ratnaningtyas et al., 2023), SMP Muhammadiyah 8 Batu city (Susetyarini et al., 2021), MTs Muhammadiyah 1 Malang (Kartini et al., 2023) and Universitas Muhammadiyah Malang (Susetyarini et al., 2022).

Thus, it can be said that PBL which is simultaneously linked to creative thinking skills, collaborative skills and environmental literacy has not been widely implemented. In fact, combining these three things in learning objectives has urgency. Creative thinking skills, collaborative skills and environmental literacy have a close relationship and complement each other in facing complex challenges in the current global context. Creative thinking allows individuals to produce innovative ideas in responding to environmental problems (Awan et al., 2019; Cheng, 2019; Isaksen, 2023; Mróz & Ocetkiewicz, 2021; Puccio et al.,

2022; Ritter & Mostert, 2017; Rosen et al., 2020). Collaborative skills are key in implementing these ideas through teamwork and knowledge sharing (Kozlowski & Ilgen, 2006; Martín-Hernández et al., 2022; Paulus et al., 2018; Riivari et al., 2021). Environmental literacy, on the other hand, provides a basis for understanding the impact of human activities on the environment and encourages sustainable action. The integration of the three creates synergism, where creative thinking provides innovative solutions, collaborative skills support their effective implementation, and environmental literacy guides responsible actions towards the global ecosystem.

In this regard, this research aimed to analyze the effectiveness of the problem-based learning (PBL) model in improving creative thinking skills, collaborative skills and environmental literacy of Muhammadiyah secondary school students in Batu City, East Java-Indonesia.

2. Materials and Methods

2.1 Types of research

The type of research that will be used is quasi-experimental research, namely the application of the PBL model to empower students' creative thinking skills, collaborative skills and environmental literacy. The design used in this research was Pretest-Posttest Non-equivalent Control Group Design.

2.2 Quasi-Experimental Research Procedures

This research design is quasi-experimental. The research was conducted to obtain a real picture of the differences in creative thinking skills, collaborative skills and environmental literacy of students who learn using the PBL learning model and students who study PBL and conventional or regular learning. The design used in this research was Pretest-Posttest Nonequivalent Control Group Design.

This quasi-experiment was carried out by providing treatment to the experimental class in the form of learning using the PBL model. Meanwhile, to find out its effectiveness, it is compared with a control class without treatment, meaning learning using a conventional (regular) model. The syntax or steps of the PBL model include (1) Orienting students to the problem, (2) organizing student work, (3) conducting investigations and compiling work results, (4) making presentations, (5) reflecting and evaluating. Meanwhile, conventional learning syntax includes (1) learning direction and orientation, (2) lecture/information, (3) discussion, (4) assignments. The implementation of the two models is followed by observing student learning activities and measuring creative thinking, collaborative skills and environmental literacy.

2.3 Sample

The sample in this research were students from SMA Muhammadiyah 3 (Senior High School) and SMK Muhammadiyah 1 (Vocational school) in Batu City, East Java, Indonesia for the 2022/2023 academic year. Sample determination was carried out by total sampling to determine research subjects.

2.4 Research Instrument

The instruments used include: 1) observation sheets, used to observe the implementation of RPS in the learning process, 2) tests, used to obtain data on learning outcomes for creative thinking skills, collaboration and environmental literacy. Tests are given at the beginning and end of learning. The assessment rubric consists of critical thinking, collaborative skills and environmental literacy rubrics.

Many assessment rubrics can be used to assess creative and critical thinking skills independently. Strategies for assessing creative thinking skills can use rubrics, checklists, peer/self-assessment, and reflection can also be supported by progress notes, observations, and anecdotal notes (Adnan et al., 2019; Brata et al., 2023; Evans, 2020). The form of assessment used must be adjusted to the targets, objectives and learning outcomes. Creative thinking skills in this study were measured using creative thinking skills test questions in the form of essays referring to four indicators of fluency, flexibility,

originality and elaboration (Armadi & Sihabuddin, 2021; Ayu et al., 2023; Firdaus et al., 2018; S. A. Handayani et al., 2021; Nada & Sari, 2022; Saputri et al., 2023). Below is a rubric for creative thinking skills (Greenstein, 2012), as in Table 1.

Table 1. Aspects of measuring creative thinking skills

Aspect	Criteria			
	Advance (score 4)	Proficient (score 3)	Basic (score 2)	Beginner (score 1)
Curiosity	The answer displays 4 relevant questions regarding a phenomenon	The answer displays 2 relevant questions regarding a phenomenon	The answer displays 1 question in the discourse	The answer doesn't show the relevant question
Fluency	The answers give rise to several alternative ways to solve the problem and their objectives	The answer raises several alternative ways of solving it	The answer raises 1 alternative solution without explaining the goal	The answer does not raise a relevant alternative solution
Originality	The answers gave rise to 2 new ideas and products innovative	Answers give rise to 1 innovative new idea	Answers bring up ideas in the discourse	Answers do not generate ideas
Elaboration	Answers display detailed explanations and add some existing facts	The answer displays a detailed explanation and adds 1 existing fact	Answers provide explanations and do not add to existing facts	Answers do not provide explanations and do not add facts
Flexibility	The answer displays 4 new possibilities that will occur in learning and everyday life	The answer shows 2 possibilities that will occur in learning and everyday life	The answer displays 1 possibility that will occur in learning and daily life	The answer does not show the possibilities that will occur in learning and everyday life
Divergent	Answers refer to the combination, adaptation, or modification of several ideas to solve a problem	Answers refer to the combination, adaptation, or modification of 1 idea to solve a problem	Answers refer to existing ideas to solve problems (do not combine, adapt, or modify)	Answers do not lead to solutions to problems

Collaborative skills consist of working productively, showing respect, compromise, and responsibility (Greenstein, 2012). This aspect has been used in the Indonesian context by Ilma et al (2022), as in Table 2.

One of the instruments that is widely used in research is the 2006 version of the Middle School Environmental Literacy Survey/MSELS instrument which has been developed and improved by experts (B. McBeth et al., 2011; McBeth et al., 2014; W. McBeth & Volk, 2009). This instrument is quite comprehensive as many researchers in various countries use it, which is why this dissertation prefers to use this instrument. This instrument covers the following: (1) Ecological Knowledge; (2) Verbal Commitment; (3) Environmental Sensitivity; (4) Environmental feelings; (5) Issue Identification; (6) Issue Analysis; (7) Action Planning; and (8) Actual commitments. Table 3 describes the aspects of environmental literacy measured in the research and their scoring.

2.5 Data analysis

Quantitative data were analyzed using inferential analysis to determine the significance of differences between the control and treatment classes. The proposed hypothesis was tested using ANACOVA with the independent variable PBL learning model. Meanwhile, the dependent variable is creative thinking skills, collaborative skills and environmental literacy.

Table 2. Aspects of collaborative skills measurement

Aspects of Collaborative Skills	Very Good (score 4)	Good (score 3)	Fair (score 2)	Less (score 1)
Work productively	Uses all time efficiently to stay focused on tasks and produce required work. Each group member does his or her job	Collaborates well and mostly stays on task until team members complete the work. Each team member performs almost all assigned tasks	Sometimes working together, but not all team members contribute or do their work, making it difficult to get the job done	It really doesn't work well together. All team members want to do their own thing and tell other team members what to do so they don't focus on the task
Show respect	All team members respectfully listen and discuss the ideas shared	Most team members listen and interact respectfully	Some team members have difficulty respecting other people's ideas	Members do not want to listen to others and argue with teammates
Compromise	All team members are flexible in working together to achieve common goals	Compromise to advance and complete group work more quickly	Requires more team members to compromise to make work faster	There was a lot of disagreement, and some team members wanted it just their way
Responsibility	All team members do their best work and follow the assigned tasks	Most of the team members work on the assigned tasks	It is difficult to get all team members involved in group work	Really can't rely on all team members to do their jobs

Table 3. Measurement of Environmental Literacy

Components of environmental literacy	Specific conceptual variables and parts of the MSELS	Item number	N items	Range
Ecological knowledge	Ecological knowledge (Part II: Ecological Foundations)	5 - 21	17	0-17
Environmental affect	Environmental Sensitivity (Part V: You and Environmental Sensitivity)	46-56	11	0-55
	General Environmental Feelings (Part VI: How You Feel About the Environment)	57, 58	2	0-10
Cognitive skills	Issue Identification (Part VII.A: Issue Identification)	59, 60, 67	3	0-3
	Issue analysis (Part VII.B: Issue Analysis)	61-66	6	0-6
	Action Planning (Part VII.C: Action Planning)	68 - 75	8	0-20
Behavior	Actual Commitment or Pro-environmental Behavior (Part IV: What You do About the Environment)	34 - 45	12	0-60

(Source: W. McBeth & Volk, 2009).

3. Results

3.1 Initial Performance

Researchers collected data related to students' initial performance of creative thinking skills, collaborative skills and environmental literacy, as presented in Table 4. Table 4 shows that there is still a need to improve creative thinking skills, collaboration skills and environmental literacy. Apart from gap data, the results of interviews regarding the science learning process nature to teachers is reported as follows: 1) teachers use regular learning methods such as lectures, questions and answers (discussions) and assignments

(making papers and presentations); 2) Students' creative thinking skills have never been measured; 3) observations have never been made on students' collaborative skills; and 4) students' environmental literacy has never been measured.

Table 4. Initial Performance of Student Creative Thinking Skills, Collaborative Skills and Environmental Literacy,

No	Variable	Aspect	Average	Category
1	Creative thinking skills	Curiosity	52.65	Basic
		Fluency of thinking	51.76	Basic
		Authenticity of thinking	53.17	Beginner
		Elaboration	52.21	Beginner
		Flexibility of thinking	52.18	Beginner
		Divergent thinking	52.32	Beginner
		Work productively	51.71	Basic
2	Collaboration skills	Show respect	53.29	Beginner
		Compromise	53.71	Beginner
		Responsibility	51.33	Not enough
3	Environmental literacy	Ecological knowledge	20.71	Low
		Environmental attitudes	19.59	Low
		Environmental behavior	18.81	Low
		Cognitive skills	19.37	Low

This research was conducted to analyze the effectiveness of the PBL learning model in improving creative thinking, collaborative skills and environmental literacy of Muhammadiyah high school and vocational school students in Batu City. At SMA Muhammadiyah 3, learning using the PBL model is carried out in class 11 with material on the respiratory system, while at SMK Muhammadiyah 1, it is carried out in class 11 with material on post-harvest handling. Preliminary data shows that students' creative thinking skills, collaborative skills and environmental literacy are still low and need to be improved. According to the statement of the subject teacher in charge of learning, it can be seen that there has never been any implementation of learning using the PBL model, no assessment has ever been carried out to determine students' creativity, no an assessment has never been carried out to determine collaborative skills and an assessment has never been carried out to determine students' environmental literacy.

Based on these objectives, it is necessary to detail the performance of PBL on the variables studied. The research results show that the creative thinking aspect is as stated in Table 5.

Table 5. The Value of Creative Thinking skills

No	Aspects of creative thinking skills	Category (%)			
		Advanced	Proficient	Basic	Beginner
Pretest					
1	Curiosity	20.00	20.00	26.70	33.00
2	Fluency of thinking	10.00	33.33	50.00	6.67
3	Authenticity of thinking	13.00	16.70	43.30	26.70
4	Elaboration	16.70	13.30	26.70	43.30
5	Flexibility of thinking	13.30	16.67	30.00	40.00
6	Divergent thinking	3.33	30.00	30.00	36.67
Posttest					
1	Curiosity	56.70	30.00	10.00	3.30
2	Fluency of thinking	20.00	46.67	30.00	6.67
3	Authenticity of thinking	23.00	23.30	33.30	20.00
4	Elaboration	63.30	13.30	10.00	13.30
5	Flexibility of thinking	40.00	23.33	23.30	13.33
6	Divergent thinking	6.67	33.33	30.00	30.00

The research results relating to students' collaborative skills are presented in Table 6.

Table 6. The Value of Collaborative Skills

No	Aspects of collaboration skills	Very good	Good	Enough	Not Enough
Pretest					
1	Work productively	17.00	43.30	23.00	17.00
2	Show respect	23.30	20.00	50.00	6.67
3	Compromise	20.00	16.67	46.70	16.67
4	Responsibility	33.30	10.00	23.30	33.33
Posttest					
1	Work productively	50.00	43.30	3.30	3.30
2	Show respect	63.30	20.00	13.33	3.33
3	Compromise	46.70	16.67	30.00	6.66
4	Responsibility	66.70	16.67	6.67	10.00

The research results related to students' environmental literacy are as presented in Table 7.

Table 7. The value of environmental literacy

No	Aspects of environmental literacy	Very good	Good	Enough	Not Enough
Pretest					
1	Ecological knowledge	13.00	46.70	20.00	20.00
2	Environmental attitudes	13.30	40.00	26.67	20.00
3	Behavior	20.00	20.00	26.70	33.33
4	Cognitive skills	66.70	6.66	20.00	6.67
Posttest					
1	Ecological knowledge	27.00	66.70	17.00	0
2	Environmental attitudes	80.00	6.66	13.33	6.66
3	Behavior	40.00	20.00	33.30	13.33
4	Cognitive skills	93.30	6.66	6.67	0

3.2 Critical thinking

The results of the research were then analyzed using ANCOVA. The results of the various effectiveness of PBL and Regular learning models on students' creative thinking can be seen in Table 8.

Table 8. ANCOVA Results for Creative Thinking skills

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	56429.066[a]	3	18809.689	186.169	.000	.843
Intercept	20371.705	1	20371.705	201,629	.000	.660
XCreative thinking	8.103	1	8.103	.080	.778	.001
Class	55470.985	2	27735.493	274.512	.000	.841
Error	10507.702	104	101.036			
Total	649645.000	108				
Corrected Total	66936.769	107				

a. R Squared = .843 (Adjusted R Squared = .838)

From the variance as in Table 8, it can be concluded that the learning model influences student creativity. Next is testing which treatments are significantly different from the LSD test as presented in Table 9.

Table 9. LSD Creative Thinking skills test results

Class	Pretest	Posttest	Corrected Mean	BNT notation	Enhancement
PBL	45.5	81.75	81.939	a	79.67%
Conventional	40.2222	42.25	42.247	c	5.04%

Table 9 shows significant differences in the Regular/conventional learning model, this can be seen from the highest final test average score in the PBL class (71.39), and Regular/conventional (14.18).

3.3 Collaborative Skills

The results of variations in the effectiveness of PBL and conventional learning models on collaborative skills are seen in Table 10.

Table 10. ANCOVA Results of Collaborative Skills

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	71232,590[a]	3	23744.197	127.249	.000	.786
Intercept	20741,292	1	20741.292	111,156	.000	.517
Xcollaborative	1.460	1	1,460	.008	.930	.000
Class	60205.225	2	30102.612	161,325	.000	.756
Error	19405.957	104	186.596			
Total	329869.000	108				
Corrected Total	90638.546	107				

a. R Squared = .786 (Adjusted R Squared = .780)

Table 10 shows the differences in learning models [F count = 254.00 with p-value = 0.00. P-value < α (α = 0.05)]. Therefore, the hypothesis that the learning model influences students' collaboration skills is accepted, then the LSD test is carried out and the results can be seen in Table 11.

Table 11. LSD Collaborative Skills test results

Class	Pretest	Posttest	Corrected Mean	BNT notation	Enhancement
PBL	11.3056	78.9444	78.887	a	598.28%
Conventional	15.5278	16.0556	16.119	c	3.40%

Table 11 shows significant differences in learning models, and this can be seen from the highest posttest average scores in the PBL (15.40) and conventional (6.72) classes. The research results show that the learning model influences students' collaborative skills.

3.4 Environmental Literacy

The pretest and posttest results of the effectiveness of PBL and conventional learning models on environmental literacy are seen in Table 12.

Table 12. Mean Environmental Literacy Pretest Posttest Score

No	Variable	Pretest	Posttest
1	PBL	58.41	77.78
2	Conventional	57.14	66.01

The results of the ANACOVA test on the environmental literacy variable show that the learning model has a significance value of 0.000, smaller than alpha 0.05 ($p<\alpha$). The research hypothesis is accepted, meaning that there is an influence of the PBL learning model on students' environmental literacy. A summary of ANACOVA's results on the environmental literacy variable k is presented in Table 13.

Table 13. ANACOVA Results for Environmental Literacy Variables

Source	Sum of Square	Df	Mean Square	F	Sign
Corrected Model	7150.868	6	1191.811	10.282	0.000
Intercept	15867.985	1	15867.985	136.903	0.000
Environmental Literacy	269.181	1	269.181	2.322	0.131
Learning model	6126.142	2	3063.071	26.427	0.000
Error	10547.545	91	115.907		
Total	581519.274	98			
Corrected Total	17698.413	97			

R squared= 0.404 (Adjusted R Squared= 0.365)

The ANACOVA results for the learning model showed significant results, namely that there was an influence of the model on students' understanding of environmental literacy. The analysis was continued with the LSD test at a significance level of 0.05 to determine the corrected mean differences in each learning model (Table 14).

The LSD test results show that there are differences in the average corrected scores of students' environmental literacy in each learning model. The corrected mean of the PBL model compared to conventional (65,479). The difference in notation between the two learning models can be interpreted as meaning that the average corrected score is significantly different from conventional.

Table 14. LSD Model Test Results on Environmental Literacy

Model	Average		Corrected Mean	Enhancement (%)	LSD notation
	Pretest	Posttest			
PBL	58.412	77.777	77.492	33.15	a
Conventional	57.142	66.005	65.479	15.51	b

Table 14 shows that the average environmental literacy of students has increased in PBL learning. Improvement occurred not only in the attitudinal aspect, but also in the behavioral aspect.

4. Discussion

The PBL model is an innovation in learning that can be used, because PBL aims to train students in critical, creative and rational thinking, actively collaborate and communicate, and increase understanding of the material being taught and provide students with real experiences. Problem-based learning is seen as a potential approach in promoting sustainable development with the assumption that graduates will learn better when what they learn is meaningful, relates to real-life situations and allows them to be directly involved. The PBL learning model aims to obtain solutions to social problems and promote student creativity (Akor et al., 2019). The PBL model emphasizes three theoretical principles of learning including cognitive learning, collaborative learning and content (Lehmann et al., 2008). The principles of PBL are student-centered and able to motivate and gain commitment from students, problem-oriented and not subject-oriented, focused on the learning process to find solutions, project-based with goals and action for change, prioritizing team formation and work, skills social and communication (Brundiers & Wiek, 2013; Ghani et al., 2021; Reed et al., 2020; Yusof et al., 2016).

PBL is closely related to the development of critical thinking. PBL is a learning approach that emphasizes contextual problem solving, where students are faced with real situations or problems that require analytical, evaluative and solution thinking. In this context, PBL motivates students to develop their critical thinking skills because they must

explore information, identify problems, formulate questions, and seek relevant solutions (Abdurrokhman et al., 2023; Hayuana et al., 2023; Maulana et al., 2022; Nurdin & Uleng, 2023).

Through PBL, students not only gain knowledge, but also learn to question, analyze and assess information critically. The critical thinking process arises because students are given the task of solving complex problems, considering various points of view, and making decisions based on evidence and logical thinking (Rahmat et al., 2020). Therefore, PBL plays an important role in developing critical thinking skills, because students must be actively involved in solving problems and making informational and contextual decisions (Abdulah et al., 2021; Maulana et al., 2022).

The PBL learning model provides the highest contribution to students' collaborative skills compared to conventional PBL. It involves students in productive work, mutual respect, compromise, and responsibility in completing group assignments. Students must express their own opinions and discuss together to determine the right solution to overcome environmental problems. This is in accordance with the research results of Sturner et al (2017) which stated that students who are active in a group at least have knowledge about something.

Collaborative skills in aspects of productive work appear when students identify and analyze problems, plan action steps and carry out actions. Problem identification and analysis activities are carried out when students have succeeded in determining the factors that influence the emergence of the problem being studied. Productive work is recorded when students design action planning activities regarding solving problems encountered. Each group has a leader who helps the teacher to divide tasks within the group. The activity of designing an action plan is carried out by preparing tools and materials, compiling work procedures, and making an activity schedule (Alphrazy & Octavia, 2023; Kozlowski & Ilgen, 2006; Thornhill-Miller et al., 2023). Productive work can be achieved through dividing tasks in groups. Dividing tasks into groups will train students to be responsible (Cheruvelil et al., 2020). Responsibility is not only about punctuality in submitting assignments, but more about achieving the best work (Greenstein, 2012).

Collaborative skills in the aspect of mutual respect are seen when students have discussions with fellow group members and when presenting results outside the group. Students carefully listen to suggestions or ideas given by other groups. This is in accordance with Greenstein (2012) who states that mutual respect can be achieved through group learning activities. Apart from that, O'Leary et al (2012) reported that mutual respect can provide positive energy to others. Similar things were recorded when students reported group progress, students conveyed the obstacles they faced and then other groups provided solutions.

There was a significant difference found between PBL and conventional in increasing students' collaborative skills. It turns out that PBL steps make a big contribution to developing students' collaboration skills through the process of observation, identification and analysis, action plans, implementation of monitoring and evaluation actions and follow-up plans (Hidayati & Wagiran, 2020; Sajidan et al., 2022). This is in accordance with previous research which explains that student collaboration can be improved through identifying problems, preparing an investigation plan, conducting investigations, compiling work results and conducting evaluations (Gholam, 2019; Pedaste et al., 2015).

PBL is significantly different from conventional learning. This is because conventional classroom learning is unable to facilitate the development of students' collaboration skills. Learning in conventional classes only carries out knowledge transfer activities, which are carried out individually without actively involving students in learning. Learning in conventional classes only provides assignments in the form of questions with a lower level of cognition (Coman et al., 2020; Lombardi et al., 2021; Rawashdeh et al., 2021). Students' collaboration skills are difficult to develop in learning that only emphasizes memory, understanding and analysis (Hasan et al., 2023).

PBL has a significant relationship with environmental literacy because both can strengthen each other in providing an in-depth understanding of environmental issues.

PBL introduces students to real situations or problems that are often related to the environmental context. By focusing learning on environmental issues, PBL provides opportunities for students to explore aspects of environmental literacy, such as understanding human impacts on ecosystems, waste management, natural resource conservation, and sustainable action (Carrió Llach & Llerena Bastida, 2023; Suryawati et al., 2020; Turcotte et al., 2022; Yew & Goh, 2016).

PBL can also develop environmental literacy by encouraging students to search for, analyze and present information related to environmental issues. In addition, through a collaborative process in solving problems, students can understand the complexity of environmental challenges and consider various perspectives in developing sustainable solutions. Thus, PBL not only teaches environmental concepts, but also builds essential environmental literacy skills to face global challenges in maintaining environmental sustainability.

5. Conclusions

This research concludes that PBL is effective in improving creative thinking skills, collaborative skills and environmental literacy of Muhammadiyah secondary school students in Batu City. There is an influence of PBL learning on students' creative thinking skills. This is shown by the results of the ANCOVA hypothesis test with F count = 1.667 with a p value = 0.000 while the p value <α (α = 0.05). Then the LSD test showed a significant difference between the conventional learning model and PBL. This was reflected in the average posttest score. The highest PBL score (24.66), followed by conventional learning (21.18). There is an influence of the PBL learning model on students' collaborative skills. This is shown by the results of the ANCOVA hypothesis test F count = 254.006 with p-value = 0.000. P-value < α (α = 0.05). Then the LSD test shows a significant difference between the PBL and conventional learning models. It can be seen from the highest posttest average score in the PBL (13.08) and conventional (6.72) classes. There is an influence of PBL learning on students' environmental literacy. This is shown by the results of the ANCOVA hypothesis test with F count = 1.667 with a p value = 0.000 while the p value <α (α = 0.05). Then the LSD test showed a significant difference between the conventional learning model and PBL. This was reflected in the average posttest score. The highest PBL score (24.66), followed by conventional learning (21.18).

Based on the findings of this research, it is necessary to develop the impact of PBL learning models on students' critical thinking skills and communication skills to complement the 21st century life skills. This research needs to be expanded by comparing other innovative learning models, such as project, discovery, inquiry and cooperative.

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