Problem-based learning model on the collaboration and computational thinking skills

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Abstract
Current education follows the skills available in the 21st century in order to create students who are ready for the future. Students can learn these skills during classroom learning activities using innovative learning models that the teacher has designed. The research aims to determine the effect of problem-based learning (PBL) on the collaboration and computational thinking skills of class VIII and to test the effectiveness of using problem-based learning on the collaboration and computational thinking skills of class VIII. This research is quantitative, quasi-experimental research. The population used in this research was class VIII 2023/2024 students. The sample in this study consisted of 2 classes. The experimental class uses a problem-based learning model, and the control class uses the model used by the teacher. Data collection uses observation sheets, survey instruments for collaboration skills, as well as test instruments for computational thinking skills. Test the research hypothesis using the one-way ANOVA test with the research results. The results of the research are that problem-based larning influences the collaboration and computational thinking skills of class VIII. The problem-based learning model is effective in empowering collaboration and computational thinking skills of class VIII students.

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1. Introduction

21st century skills are a set of competencies and skills that are the basis for student success in the complex and globally connected modern era. There are 21st century skills, namely collaboration, critical thinking skills, communication, problem solving, innovation, and creativity (Thrilling & Fadel, 2007). Collaboration skills are an activity consisting of two or more people who establish good communication between group members and then optimize the exchange of knowledge or opinions for understanding with others. Indicators of collaboration skills are social process skills, which include aspects of participation, perspective taking, and social regulation, and indicators of learning and knowledge-building skills, which include aspects of relationships, rules, and hypotheses (Griffin & Cere, 2014). Collaboration skills are important in the 21st century because in their continuity, students will plan their activities to achieve goals related to completing certain tasks or problems that require interaction with other students, such as listening and speaking, leading, and following in groups so that students can adapt to other people. Others both now and in the future (Griffin & Cere, 2014). In collaborating, student must have social and cognitive process skills when completing work to create new ideas and products or solve problems.

Current technological developments must be balanced with human thought patterns that are built on the strengths and limitations of computing, whether humans or computers carry out the process. Computational thinking is thinking that is arranged logically and systematically to solve problems in various areas of life (Wing, 2006). There are four indicators, decomposition, pattern recognition, abstraction, and algorithms (Wing, 2006). The concept of computational thinking emphasizes that students can divide problems into smaller ones, find patterns to solve similar problems, focus on important things, and formulate appropriate steps in solving problems, so computational thinking is an important basic skill in the 21st century. Prepare students to achieve success and develop in a society that is increasingly connected with technology so that the integration

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of computational thinking concepts can be included in the curriculum in various subjects at school (Wing, 2006; Voskoglou & Buckley, 2012).

Based on the results of interviews with science teachers at SMP, This is because students rely more on their friends who dare to express opinions or answer the teacher's questions, and in group work, only one of the students who stands out works so this does not trigger students to have collaboration skills. Apart from that, there is a lack of learning that is contextual to everyday problems so that it does not trigger students to think computationally. To tearchers always inovate and use varied learning models to increase students' enthusiasm for learning in class.

In mixed material learning, problem solving is involved in the context of mixed separation. Students will learn to collect, analyze, and interpret data or information packaged in collaboration and computational thinking so that students can prepare themselves for success in an increasingly digitalized world, where the ability to work together and understand computing concepts is critical. The choice of learning model used must be appropriate. Problem-based learning models can be applied. Problem-Based Learning (PBL) is a learning model in which students learn concepts and principles through problem solving, of course involving students in solving problems that are real problems in contexts that are relevant to learning (Arends, 2012). The syntax of the problem-based model is orienting students towards problems and hypotheses, organizing students to learn, conducting individual and group investigations, developing and presenting students' work, and analyzing and evaluating the problem solving process (Arends, 2012). This learning model was chosen because it allows students to develop thinking skills such as reasoning, communication and collaboration when solving problems. The problem-based learning model can be used to help students answer existing problems in their surroundings, such as in mixture separation material. Students can apply the concept of separating mixtures to find solutions. This can stimulate problem solving skills by collaborating and determining solutions using computational thinking. In this discussion, students can share ideas, provide input, and jointly design problem-solving strategies.

This research was conducted with the aim of finding out the effect of the Problem-Based Learning model on the collaboration and computational thinking skills of class VIII students at SMP SMP X. This is because it is considered new and will be applied to future learning. Students are expected to develop skills to work together to solve problems. This creates a learning environment that reflects the dynamics of the modern world of work, where teamwork and the application of computing concepts are often the keys to success.

2. Method

This research uses a quantitative experimental research design that is quasi-experimental in nature. This research was conducted at SMP X in the even semester of the 2023/2024 academic year. The sample was determined by random sampling from the population of class VIII at SMP.

The data collection technique uses learning instruments, namely teaching modules that contain learning material, and learning steps, while research instruments are observation sheets and student response surveys to measure collaboration skills, as well as tests to measure computational thinking skills. Before the instrument was used, an expert validity test was carried out, and validity and reliability tests were used the Rasch model. The results of the learning instrument validation test used expert validation, which stated that 91% of the learning instruments were valid. Meanwhile, the observation sheet instrument was analyzed using the Gregory test with a result of 100%, the survey instrument used the Gregory test and Rasch model analysis with results of Cronbach's alpha reliability of 0.93 (very good), person reliability of 0.92 (very good), item reliability of 0.70 (Enough). The test instrument uses the Gregory test and Rasch model analysis with Cronbach alpha reliability results of 0.75 (good), person reliability of 0.72 (fair), and item reliability of 0.89 (good).

The data analysis technique involves conducting prerequisite tests for data normality using the Kolmogorov-Smirnov test and for data homogeneity using the Levene test, both at a significance level of 0.05 with the IBM SPSS Statistics 25 software. The research hypothesis is tested using the one-way ANOVA test at a 0.05 significance level, along with the N-Gain test. In the N-Gain test, a g value of 0.7 or higher indicates a high category, a g value between 0.3 and 0.7 indicates a medium category, and a g value below 0.3 indicates a low category.

3. Results and Discussion

3.1. The Influence of the Problem-Based Learning Model on Students Collaboration Skills

Based on research conducted on class VIII students at SMP X shows that there is an influence of the Problem-Based Learning model on collaboration skills. This can be seen from the results of observations during learning activities.

Table 1 Results of Collaboration Skills

Data Description	Control Class	Experimental Class
Average	81	90
Minimum value	70	78
Maximum value	92	99

Based on Table 1, the average score for collaboration skills in the experimental class was higher than that in the control class. The scores at each stage of collaboration skills were compared between the control and experimental classes, and the following are the average results for each stage.

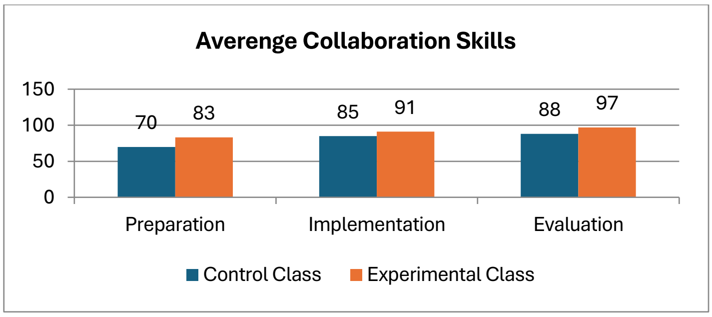

Figure 1. Average Results for Each Stage of Collaboration Skills

Based on Figure 1, the experimental class outperformed the control class in the preparation, implementation, and evaluation stages of collaboration skills. These results were then analyzed using a prerequisite test.

The results of the normality test for collaboration skills showed a significance value of 0.128 for the control class and 0.100 for the experimental class, indicating that the data is normally distributed (significance value > 0.05).The results of the homogeneity test for collaboration skills in the control and experimental classes were 0.94. These results show that the data is homogeneous because it has a significance value of>0.05. After completing these prerequisite tests, hypothesis testing was conducted.

Table 2 First Hypothesis Test Results

Hypothesis testing	Sig.	Decision
Collaboration skills	0,000	H_{a1} is accepted, there is a significant difference

Based on Table 2, the results of hypothesis testing in the control and experimental classes regarding collaboration skills are 0.000<0.05, which means there is a significant influence.

Overall indicators of collaboration skills at the preparatory stage in the control and experimental classes can be seen in the syntax of introducing problems, the collaboration skills of students in the experimental class are more likely to participate in class participation. In recognizing problems, students actively participate in identifying problems in the school environment, students identify water pollution problems in the school environment and look for the causes. This makes students also pose real problems that require an understanding of science concepts to solve them. Students actively collaborate to find sources of information and determine solutions to problems to gain understanding. Problems are presented in student worksheets, which students do to solve problems. This is in line with research regarding learning with PBL which is more effective in solving problems and has begun to contribute actively in raising and solving problems (Mulyadi, et al., 2024).

Apart from that, PBL helps students work together to process the problems presented (Prasutri, et al., 2019). In the first syntax, it can be seen that the experimental class has better collaboration skills than the control class because according, to observation results, more people participate in class participation.

In the next preparation stage, namely in the second syntax, control class collaboration skills and experimental activities, students will be organized to study in groups. Group activities can train students to see problems from different points of view and understand the diversity of perspectives in dealing with problems. This requires a scientific attitude of curiosity when discussing so that it can provide more encouragement for collaborative activities than just instructions from the teacher for students to work together. The teacher's role as a facilitator is crucial in guiding students' activities to find solutions to the problems presented (Prasutri, et al., 2019). In the second stage, it is evident that the experimental class demonstrates better collaboration skills compared to the control class.

Figure 2 Student Discussion Activities

At the implementation stage of collaboration skills, it can be seen in the third syntax, in this syntax there are differences in activities between the control and experimental classes. There are no experiments in the control class because students only carry out activities looking for material or information according to the teacher's direction, while the experimental class has experiments so that students are directly involved in learning or are student-centered (Hotang, 2019). In the experimental class, almost all students participated in the experimental activities, the students were enthusiastic about carrying out the activities, the activities carried out had been assigned to group members according to their distribution. Task-setting skills can be seen by students carrying out experimental preparations, namely taking experimental tools and materials, cutting bottles, looking for cloudy water or mixing water and sand, arranging the filtration sequence for the bottle that was cut earlier, and then pouring the cloudy water into the filtration tool and getting the resulting water clear.

In this third syntax, students are able to understand the concepts involved in the investigation, water pollution consists of a mixture of turbid and sandy water, so with turbid water, students can explain the meaning of mixture and can distinguish between compound and mixed elements. The mixture of water and sand has been separated as a form of effort to overcome water pollution in the school environment. Students gain knowledge about making and separating the mixture. Then, record the results of the experiment, which are then analyzed, and the results are linked to the material and written down on students' worksheets systematically and can make connections between problems, experiments, and results. The experimental activities carried out encourage students to obtain relevant information or data related to the problems being solved (Masruroh & Arif, 2021). Learning using the Problem-Based Learning model includes learning that prioritizes student-centeredness so that students build their own knowledge by being more active in learning (Hotang, 2019). Then, because students sense of responsibility begins to increase during experiments and discussions and completing assignments given by the teacher (Mulyadi et al., 2024).

Figure 3 Student Experiment Activities

The next implementation stage is in the fourth syntax, namely the presentation of experimental results. Students interact synergistically in front of other students, complement each other, and provide constructive feedback and the teacher provides evaluations to students who present so that they can become input for improving experimental results. This input is well-recorded by students. Presentations can help students perfect their writing and provide opportunities to share the ideas explored in their studies. This is in line with research regarding students communicating verbally or in writing to exchange thoughts or opinions with group members effectively (Mulyadi et al., 2024). Apart from that, feedback provided by other students or teachers can improve collaboration skills and student motivation. (Kandel, et al., 2023). Presentation activities in the control class used the model used by the teacher who had been accustomed to carrying out presentation activities so that students' collaboration skills in this syntax looked good and almost the same as in experimental class.

Collaboration skills contained in the final syntax of the activities carried out are the final evaluation of learning, discussions carried out by teachers and students to see whether the solutions used to overcome water pollution are appropriate or not, it can be seen that all the experimental results obtained clear water, this shows that the filtration can solve the problem of cloudy water or a mixture of water and sand in experiments. As a result of this learning, students can build knowledge about mixed materials through experimental activities. PBL can facilitate students in learning activities that begin with a problem in groups so that students gain collaboration skills and improve understanding and learning outcomes. This result was less visible in the control class because it was difficult for students to determine the correct final solution because they only received information and no experiments were carried out, so it only became written knowledge and the actual situation was not known. This is in line with research (Fitriyani, et al., 2019) that giving PBL students worksheets in experimental classes makes students more enthusiastic and serious in discussing to get solutions or information.

The results of this research are Problem-Based Learning models influence collaboration skills. This can be seen from the results of learning carried out in the experimental class which contains all indicators of collaboration skills, students can build knowledge about mixed material through experimental activities. This is because the PBL model can facilitate students in learning activities that begin with a problem. Through mixed separation experimental activities, which is a process in the nature of science that encourages students to collaborate, which is characterized by joint solutions in dividing tasks, discussing and developing joint solutions, which is in line with collaborative learning theory, which emphasizes the importance of social interaction in learning (Hertz et al, 2009). PBL is also in line with constructivism theory, students build new knowledge based on experiences and data they collect themselves, thereby increasing understanding of science concepts, involving students in investigations with a scientific attitude which is very important in the nature of science to construct students' understanding, helping students to be independent learn and be confident in the skills they have so they can be applied in everyday life (Hertz et al, 2009).

3.2. The Influence of the Problem-Based Learning Model on Students Computational Thinking Skills

Based on research conducted on class VIII students at SMP X shows that there is an influence of the Problem-Based Learning model on computational thinking skills. This can be seen from the results of the students' pretest and posttest.

Table 3 Results of Pretest and Posttest Computational Thinking Skills

Data Description	Control Class		Experimental Class	
	Pretest	Posttest	Pretest	Posttest
Average	31.45	77.42	23.06	65.05
Minimum value	8	58	8	42
Maximum value	50	92	50	92

Based on Table 3, it was found that the average pretest-posttest score for the experimental class was higher than the control class. In the experimental class, there was an increase in scores of 46, while in the control class, it was 42. The pretest-posttest scores for each aspect of computational thinking skills were compared between the control and experimental classes. Below are the average results for each aspect of computational thinking skills.

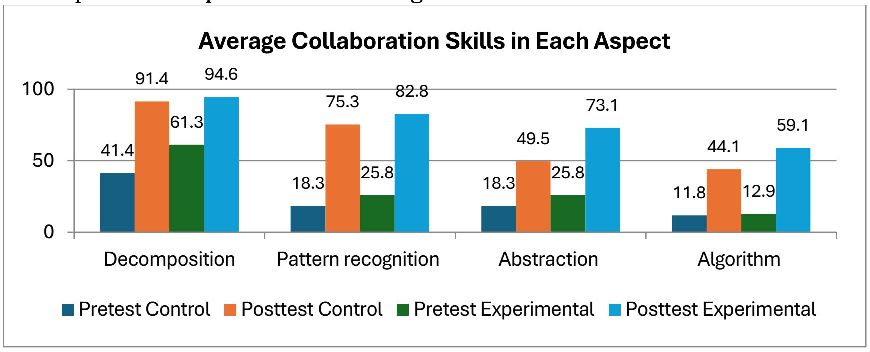

Figure 4. Average Results for Each Stage of Computational Thinking Skills

Based on Figure 4, regarding computational thinking skills for each aspect of the pretest-posttest results of the control and experimental classes, it was found that the decomposition aspect had a high mean, while the algorithm aspect had the lowest mean. The results of these values are then analyzed using a prerequisite test.

The prerequisite test results for the normality test of computational thinking skills show a significance value of 0.062 for the control class and 0.054 for the experimental class. These values indicate that all data is normally distributed, as the significance values are greater than 0.05. The homogeneity test results for computational thinking skills yielded a significance value of 0.139 for both the control and experimental classes, indicating that the data is homogeneous (significance value > 0.05). Following these prerequisite tests, hypothesis testing is conducted.

Table 4 Second Hypothesis Test Results

Hypothesis testing	Sig.	Decision
Computational thinking skills	0,000	H_{a2} is accepted, there is a significant difference

Based on Table 4, the results of hypothesis testing in the control and experimental classes regarding computational thinking skills are 0.000<0.05, which means there is a significant influence. The following are students' pretest and posttest answers from the control and experimental classes.

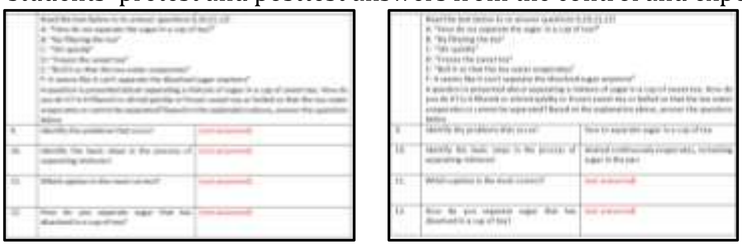

Figure 5. Control Class Pretest and Posttest Results

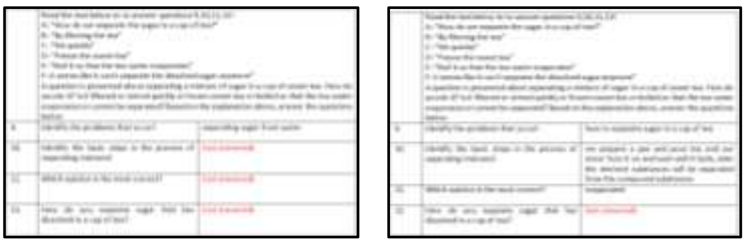

Figure 6. Experimental Class Pretest and Posttest Results

Based on Figures 5 and 6, experimental class students were able to answer computational thinking questions better than the control class. It can be seen from number 9 the decomposition indicator, number 10 the pattern recognition indicator, number 11 the abstraction indicator, and number 12 the algorithm indicator. The following is an explanation of computational thinking skills in learning activities:

Decomposition indicator

Decomposition indicators are seen in the first syntax with students' activities to identify what happens when simulating mixed material in detail. Students identify problems or break down existing problems in the school environment to find water pollution problems and identify factors influencing water pollution. They can also name the forms of water pollution into mixed types. All experimental class students have been seen to understand and solve the problems in the PBL questions. This is a learning process centered on the chosen problem, which results in students not only understanding the concepts related to the problem but also scientific techniques for solving the problem. This is in line with the aim of the PBL model to develop students' cognitive abilities and skills in solving problems logically, clearly and comprehensively (Kamid & Sinabang, 2019). Other research explains that students who still do not have the skills to decompose problems will find it difficult for students to continue working on them, which will affect their understanding of related concepts (Jamalludin et al., 2022). Apart from that, research conducted (Lestari & Ma, 2020) on students writing down the information needed to solve problems so that they can solve problems well. In this research, students decomposed the problem well, so that students understood the concept well.

Pattern recognition indicator

Indicators of pattern recognition are seen in the second syntax where students interact with each other to discuss and look at previous experiences to overcome similar problems. In the second syntax, it organizes students to learn. The teacher helps students devide their learning into group. By working in groups, students are able to see problems from different points of view from their group friends and understand the diversity of perspectives in dealing with environmental pollution problems. Then, students look for solutions that can be used to overcome them. Students can be seen interacting with each other, discussing and looking at previous experiences to overcome similar problems. This is in line with research conducted by Jamalludin et al (2022), which shows that students who use patterns make them more concise and faster in working on questions. In the results of this research, students already recognize the pattern of the questions. Recognizing almost similar patterns to solve problems is a very important indicator of computational thinking (Barrón-Estrada et al. 2022). Fifth syntax in strengthening conclusion determination. So, the PBL model has more influence on computational thinking skills in the second syntax, which contains aspects of pattern recognition.

Abstraction indicators

The abstraction indicator is seen in the first syntax, where the student's activity is to draw an outline of the simulation results, namely mixed material. After getting the problem, students focus on the problem of water pollution. Students in the sixth experimental class group were able to identify forms of water pollution into mixed types, while those in the third control class group were still unable to identify forms of water pollution, still mentioning other examples besides water pollution. The fifth syntax involves students reviewing the results of their work to ensure they match the observed facts and making conclusions. Students in group six of the experimental class were able to conclude that the results of the experiment were appropriate to the problem, while students in group three of the control class were not able to conclude the results of the experiment. This was because the students did not understand the problem and solution. In the final syntax, namely analyzing and evaluating experimental activities, students create a final solution, if the solution used is appropriate, then that solution will be used. This is included in the computational thinking indicators, namely abstraction, to focus on a main piece of information, where this information is a solution to water pollution with filtration. This is in line with the statement (Cahdriyana & Richardo, 2020) that the pattern recognition section is useful for strengthening ideas in abstraction indicators.

Algorithm indicators

The algorithm indicator is seen in the third syntax with the activity of students being able to arrange steps for separating a mixture of water and sand based on the basic steps for separating the mixture and applying it in the form of an algorithm or sequential steps to produce an effective solution. Group six students in the experimental class mentioned the work steps in sequence. Meanwhile, group three students in the control class missed a step, namely making or preparing a mixture of water and sand. During experimental activities, students can recognize patterns in the separation process, which means students can arrange steps for separating a mixture of water and sand based on the basic steps for separating the mixture and apply them in the form of an algorithm or sequential steps to produce an effective solution. This can be seen when completing the work steps. In the experiment. Students in experimental class can write experimental results into tables correctly and can describe experimental results. Meanwhile, students in the control class could only write in tables but did not describe the results of their experiments. Students in experimental classes can answer questions, analyze experimental results, and search for information correctly and according to theory. Meanwhile, students in the control class can answer questions, analyze experimental results, and search for information, but some questions are not correct and in accordance with theory.

This is in accordance with research by Jamalludin, et al (2022), students who already have high thinking abilities can understand the questions even though not all the answers are correct. Creating algorithms shows various levels of student skills because of the higher and critical thinking processes, algorithms are actually reflected in daily activities such as the steps for brushing teeth (Yadav et al. 2014). This is also in accordance with research by Sulasih et al (2018). Students who have high critical thinking skills obtain good learning results in everyday life. Students' learning outcomes reflect their natural responses when participating in learning activities, such as preparing presentations, preparing tools and materials in the laboratory, and paying attention to the course of practical work. The results of student experiments show that the PBL model has more influence on computational thinking skills in the third syntax, which contains algorithmic aspects.

In the fourth syntax, students find material and present the results of experiments using student worksheets. Students will be encouraged to ask questions, and the teacher will provide assistance, but students should try to work independently or with a group of friends first. As a result, students have solutions obtained from looking at previous events and only seeing the important things. This is in accordance with research by Jamalludin et al (2022), where students only use some important data to form solutions, while the rest of the time, students ignore other information that is considered unimportant. The PBL model has more influence on computational thinking skills in the fourth syntax, which contains algorithmic aspects.

The results of this research are Problem-Based Learning models influence computational thinking skills. This can be seen from the results of learning that has been carried out in the experimental class, which contains all indicators of computational thinking skills, students can build knowledge about mixed materials through the experimental activity of separating mixtures, which is a process in the essence of science. This is because the PBL model can facilitate students in thinking processes that involve logic in developing solutions to solving problems through the process of breaking down large problems into smaller ones, developing patterns, abstractions, and algorithms that are in line with cognitive theory in understanding, analyzing and solving complex problems. Apart from that, it is also in line with constructivism theory, where students study real world problems, which makes learning more meaningful and relevant for students, thereby preparing students to face challenges in the real world with strong computational and analytical thinking skills. PBL also helps students learn independently and be confident in the skills they have so they can be applied in everyday life.

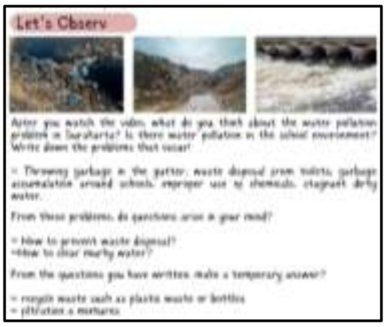

Figure 7. Decomposition, Pattern Recognition, And Abstraction Indicators in the Control Class

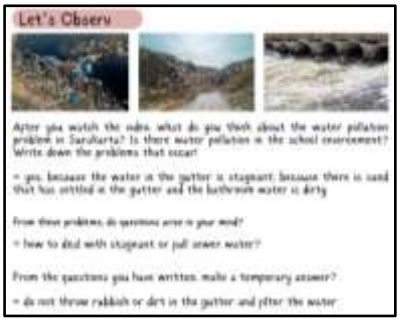

Figure 8. Decomposition, Pattern Recognition, And Abstraction Indicators in the Control Experimental

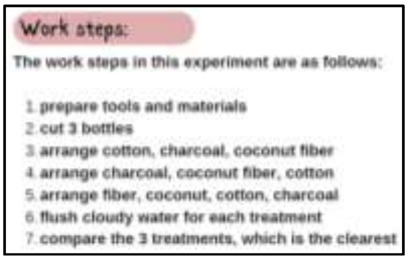

Figure 9. Algorithm Indicators in the Control Class

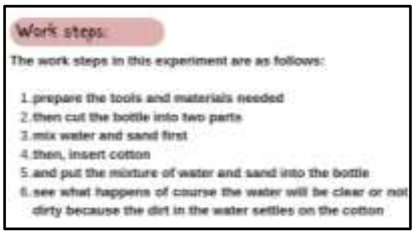

Figure 10. Algorithm Indicators in the Experimental Class

3.3. Effectiveness of Using Problem-Based Learning and Discovery Learning Models on Students Collaboration and Computational Thinking Skills

The results of data description and hypothesis testing of collaboration skills and computational thinking have been carried out, showing that there are significant differences. From the results of observations during the experiment, test results, and worksheet results, experimental class students got a higher average compared to the control class. Students in the experimental class make direct contributions to the experiment in groups so that there is interaction in it, such as cooperation in understanding existing problems, conveying ideas or concepts in overcoming problems, dividing work tasks during experiments, collecting data, compiling experimental results based on student worksheets, search for sources or information, present experimental results, and evaluate experimental results with other groups. Students also show good initiative and responsibility in completing individual or group tasks that have been set to achieve common goals (Ilmiyatni et al. 2019).

The results of the student questionnaire responses from the control and experimental classes were 78% gave positive responses, there were students who strongly agreed with learning with direct experimental activities. In line with research conducted (Mulyadi et al., 2024) the implementation of PBL has had a positive impact on efforts to improve students' collaboration skills.

Apart from that, the pretest and posttest results show that there is an influence between the control class and the experimental class as indicated by the N-gain value as follows:

Table 5 Results of the N-Gain Test for Computational Thinking Skills

Class	N-Gain Score	Category
Control Class	0.55	Currently
Experimental Class	0.67	Currently

Based on Table 5, the N-Gain test results indicate that the control class scored 0.55 (medium category), while the experimental class scored 0.67 (medium category). The higher N-Gain score in the experimental class suggests that the Problem-Based Learning model is more effective in enhancing computational thinking skills compared to the discovery learning model. (Ha3 accepted). In line with Jamalludin et al (2022), students who can determine the information that matches the indicators of computational thinking, namely, are able to break down problems into simpler ones, are able to recognize patterns, are able to use only important information, and make steps that can be categorized as good, can think computationally. This shows that the Problem-Based Learning model is more effective on students' collaboration and computational thinking skills than the discovery learning model.

4. Conclusion

The results of the research can be concluded the influence of the Problem-Based Learning model on collaboration skills in class VIII SMP more effective than the learning model used by the teacher. The Problem-Based Learning model can develop students' collaboration and computational thinking skills, equipping students in an increasingly connected and group-based work environment.

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