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IMPROVE COLLIGATIVE PROPERTIES SKILLS AND PROBLEM SOLVING ABILITY OF SMA NEGERI 1 BABALAN CLASS XII STUDENTS USING MODEL PROBLEM BASED LEARNING (PBL)

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ABSTRACT

Abstract: This study was to find out how the application of the Problem Based Learning (PBL) model to the topic of Colligative Properties in the science program at SMA Negeri 1 Babalan Class XII academic year 2021–2022 would increase students' problem-solving skills and learning activities. Three cycles of action research were used in this study. 32 SMA Negeri 1 Babalan students from the first semester of the academic year 2021–2022 served as the study's subjects. The findings came from watching students engage in learning activities and testing their capacity to solve problems at each stage of the Cycle. The results demonstrated that 1) college students' problem-solving skills improved by implementing the PBL model on the Colligative Properties subject, with average values from Cycles I to II and III of 56, 77, and 87, respectively, while the percentage of classical completion from Cycles I to II and III was 44%, 62,5%, and 87%, with gains from Cycles I to II of 0,083 and from Cycles II to II equal to 0,35; 2). Applying the PBL model to the topic of Colligative Properties resulted in an increase in the students' learning activities, with an average value of 75 in sufficient criteria, 77 in sufficient criteria, and 85 in good criteria from Cycle I to Cycle II and Cycle III, respectively.

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INTRODUCTION

Colligative qualities of solutions are a subset of intense features that depend on the solute concentration but not on the solute's chemical composition. For instance, although though salt (sodium chloride) and sugar (sucrose) have very distinct molecular structures and masses, the effects they have on the properties of solutions depend more on the quantity of sugar or salt molecules present than on their combined molecular weight. When the solute concentration in a solution changes, coagulative qualities affect what happens to the vapor pressure, boiling and freezing temperatures, and osmotic pressure. As a system strives to reach equilibrium, altering the collative characteristics alters the passage of solvent over a permeable membrane. Osmotic pressure increases with increasing solute concentration, and as sugar and salt solutions are frequently found in a variety of diets, osmotic pressure is crucial to the microbiological stability of particular foods (Wickware, Day, Adams, Orta-Ramirez, & Snyder, 2017). Colligative Properties have a lot of potential to be used as a tool for the development of different skills, as evidenced by the preceding description. One of them is the capacity for higher-order thought, demonstrated by one's capacity for problem-solving (Nurhadianti, Sari, Farida, & Irwansyah, 2023). Problem solving skills are emphasized in modern education and are considered to be an essential component of learning. Additionally, a student's capacity for problem-solving indicates how well-versed they are in a certain ide (Yusfiani, Lubis, Fuadaturrahmah, & Siregar, 2022).

Unfortunately, based on early assessments of Chemistry instruction at SMA Negeri 1 Babalan, student problem-solving skills are still not very high. The answers to questions focused on problem solving that were modified from a set of questions from chemistry textbooks could virtually never be correctly answered, according to the results of quizzes and assignments in applied physics courses from numerous previous batches of students. As a result, there are poor student learning results.

After conducting an investigation into the way students work on physics questions given by teachers, it is found that students more often directly use mathematical equations without doing analysis, guess the formulas used and memorize examples of problems that have been done to work on other problems. Students can also work on calculation questions if the questions are similar to the example questions. If the question is tricked, for example by changing what is known to what is being asked, they will be confused as if the problem has never been discussed. After looking into how students approach Chemistry problems from their instructors, researchers discovered that they frequently memorize solutions to previous problems, use mathematical equations directly without further analysis, and guess the formulas. If the calculations are comparable to the example problems, students can practice them as well (Türk & Seyhan, 2022). They will be perplexed as if the issue has never been raised if the question is misled, for example by shifting what is known to what is being asked.

Students still frequently employ the memory-based plug-and-chug method to solve physics issues. There are a number of elements that contribute to students' poor problem-solving skills. Students are unable to resolve issues like insufficient laboratory practice, uncertainty when writing unit conversions, and a lack of chemistry reference literature (Maisa, 2020). One factor in the lack of problem-solving abilities is the students' lack of enthusiasm, as well as their poor comprehension of the chemistry concepts and norms.

Ironically, even though there have been many studies showing that the use of constrictivist-based learning has succeeded in increasing learning activities in conditions that allow for the development of thinking and problem-solving skills, not many lecturers apply them in classroom learning. Learning that places more emphasis on memorizing aspects of facts rather than on concepts that explain these facts results in learning activities carried out by students limited to memorizing concepts without training their thinking and problem solving skills. Efforts that have been made by teachers to improve the learning process so that it leads to efforts to increase student activity and problem solving abilities are by applying demonstration and practicum methods. However, this method has not been able to improve the learning process because it is still weak in trying to master the concept, because it is still limited to observing and imitating practical steps to simply obtain facts from the theory being studied (Eyceyurt Türk, Gülseda Güngör Seyhan, 2022).

If science is taught utilizing the scientific method along with cognitive reasoning on the facts gathered and the observed natural occurrences, the learning experience will be engaging and pleasurable. Both professors and students may find active learning to be more enjoyable. Problem Based Learning (PBL) is one of the active learning strategies that is thought to be able to help students enhance their critical thinking and problem-solving skills (Hung, Moallem, & Dabbagh, 2019). The PBL paradigm applies student learning to challenges from real life. The PBL paradigm was created to aid students in acquiring intellectual abilities such as thinking critically, solving problems, and taking on different roles through practical learning situations. According to PBL, a learning strategy, authentic issues are used to construct student knowledge, improve higher-order thinking and inquiry abilities, and foster student independence and confidence.

Students of different ages can learn topics and activities thanks to the PBL methodology. Presenting students with real-world, relevant problem situations might help them conduct investigations and enquiries more easily. This is the PBL model phase. In essence, students encounter genuine and significant problem scenarios that might test their ability to address them. The PBL model is used to stimulate higher order thinking in problem oriented situations including how to learn. In problem-based learning, the teacher's job is to offer challenges, pose questions, and encourage research and discussion. Without teachers creating a classroom environment that encourages an open exchange of ideas, the PBL paradigm cannot be implemented (Fidan & Tuncel, 2019).

The PBL approach has numerous advantages, but there are also certain disadvantages that every teacher should be aware of before implementing it. The PBL paradigm requires a lot of time and resources, and it might not be suitable for all Chemistry materials. The PBL paradigm must be carefully planned out by the teacher (Fuadaturrahmah & Simamora, 2022).

Referring to the problems faced and all the advantages while still considering and anticipating the various weaknesses of the PBL model, researchers feel the need to apply the PBL model in Chemistry learning to improve the problem-solving skills of SMA Negeri 1 Babalan Class XII Students 2021/2022 Academic Year. Referring to the background of the problem above, the objectives of this study include; 1) to determine the increase in Collligative Properties problem solving abilities of SMA Negeri 1 Babalan for the 2021/2022 academic year using the PBL model, and 2) to determine the increase in thermodynamics learning activities of Chemistry for the 2021/2022 academic year using the PBL model in SMA Negeri 1 Babalan Class XII.

RESEARCH METHODS

Action Research is the methodology employed in this study. Since this research is mainly concerned with issues that arise in the classroom or throughout the teaching and learning process, action research is a great fit for it (Kukleva, Kuehne, Sener, & Gall, 2019). A classroom action research (CAR) design was used for this investigation. Tests, observations, field notes, and documentation are used in the data collection processes (Keahey, 2021). Data regarding pupils' problem-solving skills is gathered through tests. Data about the teaching and learning process and student learning activities are gathered concurrently using observation techniques and field notes. While using documentation to support study findings. The extent of the pupils' problem-solving skills determines the research's success. At least 85% of students must receive a perfect score (B+) for the study to be considered successful. Additionally, the normalized gain across cycles was used to calculate the improvement in students' problem-solving skills.

RESEARCH RESULTS AND DISCUSSION

1. First Cycle

Process data are observed in accordance with the planning-determined process success indicators. The information that appears while the action is carried out is then noticed and described. The following process data were noticed during this classroom action research: (1) information about the efficacy of the process for carrying out the actions carried out by lecturers or researchers, and (2) information about student activities, which include nine indicators, including: a) pay attention; b) discuss; c) ask questions; d) formulate problems; e) provide ideas; f) conduct trials of ideas found; g) gather information on practicum results; h) formulate problem solving; and i) draw conclusions. Additionally, the effectiveness of problem-solving abilities was seen in terms of success markers in learning outcomes exams.

Careful planning is necessary for this action study to produce the best findings possible. Researchers prepare the following during the planning stage:

1. The researcher carried out a curriculum analysis to identify the learning objectives to be communicated to students using the PBL model.
2. Develop a lesson plan based on the PBL model.
3. Design a worksheet.
4. Design an observation tool for the cycle of classroom action research.
5. It is to create tools for learning evaluation.

Cycle I; learning was started by the researcher acting as the lecturer by outlining the learning objectives, outlining the necessary logistics, and encouraging students to participate in the problem-solving activities they selected. The instructor then assists students in defining and planning learning tasks associated with these issues. In this instance, the lecturer splits the class into five groups of five students each, with three individuals in each group.

Additionally, researchers assist students in data collection, experimentation, explanation, and problem-solving. Additionally, researchers help students design and prepare relevant works like papers, films, and models before assisting students in sharing tasks with their acquaintances. Researchers assist students in reflecting on or evaluating their studies and the methods they employ at the conclusion of their learning.

Students' learning activities were observed while the first cycle of learning was put into place. In terms of student participation, my cycle's observations yielded an average score of 55 out of a possible 100. In this instance, the student action is categorized as sufficient, and is considered successful if it obtains a score greater than or equal to 70 (good). Nine indicators were used to gauge the observer's attention to student activities in this study: 1. Paying attention, 2. Talking, 3. Asking questions, 4. Generating problems, 5. Giving ideas, 6. Testing those ideas, 7. Obtaining information from the practicum, 8. Formulating problem-solving, and 9. Drawing conclusions are all examples of active listening.

The explanation for the low average score acquisition includes:

A. Indicator 1 : As is customary, students pay close attention to the teacher's explanation when the lecturer presents the material with an average score of 58 and sufficient criteria. However, several of the teacher's questions that are posed during the explanation cannot be satisfactorily answered by the students, indicating that the students' attention has not been able to foster understanding.

B. Indicator 2 : With an average score of 61 and sufficient criteria, some students actively participate in discussions in this indicator, although several groups appear to be unsure of what to do or debate.

C. Indicator 3 : With an average score of 61 and sufficient criteria, students have started to actively ask their professors questions, although it still focuses on how to utilize the technology rather than the actual content of the lesson.

D. Indicator 4 : Almost all groups took too long to formulate the problem, and only a few groups were successful in doing so with an average score of 51 and appropriate criteria.

E. Indicator 5 : While many students remain mute and don't participate in class, some do so actively with an average score of 56 and appropriate criteria.

F. Indicator 6 : With an average score of 55 and appropriate criteria, the students who tested the proposal usually merely worked on it without understanding the issues.

G. Indicator 7 : Inquiring about the outcomes of practicum with an average score of 56 and sufficient criteria, many students make blunders.

H. Indicator 8 : Most students are unable to come up with answers to problems with an average score of 50 and sufficient criteria because they make mistakes when generating problems, testing ideas, and gathering information on practicum findings.

I. Indicator 9 : The majority of students find it difficult to draw conclusions even with an average score of 53 and adequate criteria.

Table 1 displays the findings from the Cycle 1; teaching and learning process observation of student learning activities.

Table 1. Scores of Student Learning Activity Cycle I

No.	Student's Activity Observed	Assessment	
		Score	Criteria
1	Notice	58	Enough
2	Discuss	61	Enough
3	Ask	61	Enough
4	Formulate the problem	51	Enough
5	Give an idea	56	Enough
6	Testing ideas through practicum	55	Enough
7	Gather information on the results of the practicum	56	Enough
8	Formulate problem solving	50	Enough
9	Draw conclusions	53	Enough
	Rate	56	Enough

A final cycle test—hereafter referred to as a formative test regarding students' problem-solving abilities—was administered following the conclusion of Cycle I. The effectiveness of the process has an impact on the test's outcome. At the conclusion of the first cycle of learning, a test of students' problem-solving abilities was administered, and while the average score was 75, only 47% of the students—20 out of 32 —achieved comprehensive problem-solving abilities. Even though the average value indicates completeness, classical completeness of 85% has not been achieved. The lack of achievement of classical completeness can be used as a benchmark that the ability to solve problems is still weak. This can be seen in Table 2.

Table 2. Student Learning Outcomes Test Scores for Cycle I

No.	Score Total	Mark	
		Number	Letter
1	28	72	B
2	26	67	B
3	30	77	B+
4	28	72	B
5	28	72	B
6	28	72	B
7	23	59	C+
8	33	85	B+
9	31	79	B+
10	32	82	B+
11	33	85	B+
12	31	79	B+
13	28	72	B
14	28	72	B
15	30	77	B+

16	28	72	B
17	26	67	B
18	30	77	B+
19	28	72	B
20	28	72	B
21	28	72	B
22	23	59	C+
23	33	85	B+
24	31	79	B+
25	32	82	B+
26	33	85	B+
27	31	79	B+
28	28	72	B
29	28	72	B
30	30	77	B+
31	33	85	B+
32	31	79	B+
	Rate	75	
	Completed Students	14	
	Completeness Percentage	44%	

The failure of the process of putting the plan into action can be seen in the results of the problem-solving ability test, which show that success has not been reached in enhancing problem-solving ability in the first cycle. The first cycle's low student learning activity, which is in the adequate group, had an impact on the problem-solving ability test scores, which were only 44% complete.

Cycle I; either failed to meet the research success criteria or didn't offer thorough learning outcomes. The following are some of the reasons why this occurred. a. The observer's observations of the students' behavior while the learning activities were taking place barely met the requirements to be considered sufficient. This is based on the percentage of results for each observational component that just meet the minimum requirements.

A. The majority of the student activity indicators in cycle I revealed subpar assessment outcomes, such as pupils who remained reticent to express thoughts and construct difficulties.
B. Based on the overall exam results from the first cycle, it was determined that 44% of students, or seven students, had achieved the required level of problem-solving proficiency, while about 56% of students, or eight students, had not achieved the required level of learning and would be finished in Cycle II.
C. Student difficulties in completing problem solving tests are in the process of planning and solving problems.
D. Students who had not thoroughly acquired the prerequisite knowledge had difficulties following the learning series because there was no examination of that knowledge at the first meeting, such as knowledge of temperature, heat, and measurement.

E. Learning activities are less concentrated since expectations were not met for group formation and the dissemination of investigative information. This is evident from the group members' involvement in less focused discussion activities.

When referring to the cycle I reflection outcomes that are displayed on the front, it is clear that the majority of them are flaws in how actions are carried out when they are not done so according to protocol. The lecturers' lack of proficiency with the action processes that will be used is the main issue that influences that. This can be avoided by reading the action procedure steps again and making an effort to remember them.

2. Second Cycle

Cycle II; includes planning, implementing, observing, and reflecting as well as replanning, similar to cycle I. Making plans for cycle II based on re-planning cycle I, specifically:

A. Giving reading and literary study assignments to students who have not yet gained the prerequisite information to make it simpler for students to follow PBL processes and master the learning content.
B. Distributing remedial tasks through instructional materials that define the subjects that need to be studied independently by each student.
C. Problem solving exercises are carried out using worksheets with guided problem solution questions at each phase, the guide is solely for practice while the guide is excluded in the formative test. This is done to aid students in the planning and problem solving steps in the PBL paradigm.
D. Keep the students' attention as the teacher uses the media flash player to explain the material.
E. Establish a culture of honesty and generosity rewarding students will increase their motivation and bravery to participate more.

The teacher started Cycle II learning by defining the learning objectives, outlining the necessary logistics, and inspiring the students to participate in the problem-solving activities they selected. Additionally, the instructor assigns reading and literary studies to pupils who have not yet learned the prerequisite material and remedial work to those who did not finish cycle I. The instructor then assists students in defining and planning learning tasks associated with these issues. In this instance, the teacher splits the class into five groups of five students each, with three pupils in each group.

1. Indicator 1 : When a teacher presents content with an average score of 73 and good criteria, students pay attention to what they are being told. This is standard practice, and students' attention is growing as they learn utilizing the PBL model with media and worksheets to complete.
2. Indicator 2 : With an average score of 71 and favorable criteria in this indication, some students actively engage in discussions, but some groups continue to struggle with knowing what to do or talk.

3. Indicator 3 : With an average score of 72 and good criteria, students have started to actively ask lecturers and other students, and the caliber of the questions is beginning to influence the content of learning.
4. Indicator 4 : Despite this increase, only a small number of groups were able to appropriately formulate the problem with an average score of 59 and sufficient criteria.
5. Indicator 5 : With an average score of 61 and sufficient criteria, many students have actively contributed thoughts and comments. However, this activity needs more attention in order to meet learning objectives.
6. Indicator 6 : With an average score of 64 and appropriate criteria, many students are beginning to test concepts for interpreting real-world issues and developing solutions.
7. Indicator 7 : A few students have begun to actively gather data on practicum outcomes with a minimum average score of 60 and sufficient requirements.
8. Indicator 8 : Many students are starting to attempt to construct answers to problems with an average score of 59 and sufficient criteria as a result of increasing involvement in formulating problems, testing ideas, and accumulating information on practicum results.
9. Indicator 9 : Even though their conclusions are incorrect, many students have begun to draw them based on an average score of 61 and appropriate criteria.

Additionally, researchers assist students with data collection, experimentation, explanations, and problem-solving. To assist pupils practice problem-solving abilities, the teacher also shows videos and offers worksheets with instructions. Additionally, researchers help students design and prepare relevant works like papers, films, and models before assisting students in sharing tasks with their acquaintances. The researcher assists students in reflecting on or evaluating their research projects and the methods they employed at the conclusion of their learning.

Similar to the first cycle, the second cycle of learning included observation of student activity. The findings of cycle II observations in the area of student learning activities included the acquisition of an average score of 64 on a perfect score of 100. In this instance, the student action is categorized as sufficient, and is considered successful if it obtains a score greater than or equal to 70 (good). Nine variables that provided an explanation for the low average score were used by the observer to focus on student activities in this study.

Table 3 displays the findings from the cycle II teaching and learning process observation of student learning activities.

Table 3: Student Learning Activity Cycle II scores

No.	Student's Activity Observed	Assessment	
		Score	Criteria
1	Notice	73	Good
2	Discuss	71	Good
3	Ask	72	Good
4	Formulate the problem	59	Enough
5	Give an idea	61	Enough
6	Testing ideas through practicum	64	Enough
7	Gather information on the results of the practicum	60	Enough
8	Formulate problem solving	59	Enough
9	Draw conclusions	61	Enough
	Rate	64	Enough

From cycle I to cycle II, there was a small improvement in the capacity to solve problems. According to the results of the test on problem-solving skills administered at the conclusion of the second cycle of learning, students had an average problem-solving ability of 77 in relation to the learning material, while the percentage of students who had fully developed their problem-solving skills was only 62,5%, or as many as 20 out of 32 students. Even if the average figure shows completion and improvement over cycle I, the standard level of completion of 85% has not been met. The inability to achieve classical completeness might be used as a benchmark to indicate that one's problem-solving skills are still lacking. The Table 4., demonstrates this.

Table 4. Test Results for Student Learning Outcomes in Cycle II

No.	Score Total	Mark	
		Number	Letter
1	28	72	B
2	26	67	B
3	30	77	B+
4	28	72	B
5	28	77	B+
6	28	72	B
7	23	80	B+
8	33	85	B+
9	31	79	B+
10	32	82	B+
11	33	85	B+
12	31	79	B+
13	28	72	B
14	28	72	B
15	30	77	B+
16	28	72	B
17	26	77	B+

18	30	77	B+
19	28	72	B
20	28	72	B
21	28	72	B
22	23	81	B+
23	33	85	B+
24	31	79	B+
25	32	82	B+
26	33	85	B+
27	31	79	B+
28	28	72	B
29	28	79	B+
30	30	77	B+
31	33	85	B+
32	31	79	B+
	Rate	77	
	Completed Students	20	
	Completeness Percentage	62,5%	

The following normalized gain calculations show how problem solving skills improved from cycle I to cycle II:

$$g = \frac{S_2 - S_1}{S_{maks} - S_1}$$

$$= \frac{77-75}{100-75}$$

$$= 0{,}083$$

According to these findings, the improvement in students' problem-solving abilities is still considered modest because it is less than 0.3.

The failure of the process of putting the plan into action can be seen in the results of the problem-solving ability test, which show that success has not been reached in enhancing problem-solving ability in the first cycle. The influence of the low student learning activity in cycle II, which is in the adequate category, can be seen in the first cycle's low completion rate of the problem-solving ability test results, which was 62.5%.

Cycle II; either failed to meet the research success criteria or failed to deliver all intended learning outcomes. The following are some of the reasons why this happens.

1. Only observations of student behavior during learning activities during cycle II met the necessary criteria with issues that were nearly identical to the outcomes of cycle I.
2. Based on the overall test cycle II findings, it was discovered that 62,5% of students, or 20 students, had fulfilled the completeness requirement for problem-solving skills, while around 37,5% of students, or five students, had not.
3. Almost identical to cycle I, students had trouble preparing and solving problems for their problem-solving assessments.

4. As a measure of improving problem-solving abilities from cycle I to cycle II, learning achievement tests' normalized increase is 0.083. This value explains why the category of the normalized gain for enhancing cognitive structures is low
5. While using guided worksheets to help students solve problems has yielded some positive effects, it hasn't really improved students' problem-solving skills.
6. Even if there hasn't been much of an increase in learning activities, the employment of guided worksheets and media flash player has had enough of an impact on student learning activities.
7. The teacher's command of the action methods that will be used to address issues that develop throughout learning is not very excellent.

3. The Third Cycle

Cycle III includes planning, implementing, observing, and reflecting as well as replanning, just like cycles I and II. Cycle III planning is built on cycle II planning, specifically:

1. Give PBL model implementation using media and problem-solving exercises using guided worksheets additional time and attention.
2. In PBL steps, ideas and problem-solving techniques are shared between individuals and groups, as well as between those who have solved the problem successfully and those who have not, to enable the latter to copy the successful groups' or individuals' solutions.

Cycle III learning followed the same procedures as Cycle I and Cycle II; the only alterations were the corrective measures implemented, which included allocating more time and putting greater emphasis on leveraging media to execute the PBL model and problem-solving activities with guided worksheets. Additionally, there is a sharing of concepts and methods for problem-solving in PBL steps between individuals and groups, as well as between those who have solved the problem successfully and those who have not, so that those who have not been successful can copy the problem-solving techniques from her friend.

The average score on a scale of 100 for the outcomes of watching student learning activities in cycle III was 77. In this instance, the aspect of student activity is rated as good. An aspect of student activity is considered successful if it has a rating of at least 70 (good). In this study, the observer focused on nine measures of student engagement that provided an explanation for the low average score, including:

a. Indicator 1 : With an average score of 89 and very good criteria, students pay attention to the teacher's explanations when she teaches the content. This activity is expanding learning utilizing the PBL model with media and worksheets that must be completed, as well as awareness of the test at the end of the cycle.

b. Indicator 2 : Almost all students were attentive on the debate, and several students actively contributed with an average score of 85 and good criteria in this category.

c. Indicator 3 : With an average score of 87 and good criteria, students actively questioned professors and fellow students. These questions were of a high standard and always contributed to the learning process.

d. Indicator 4 : With an average score of 72 and good criteria, more groups have succeeded in correctly framing the problem.

e. Indicator 5 : A number of students actively contributed thoughts and opinions, scoring an average of 71 and meeting good criteria.

f. Indicator 6 : With an average score of 71 and good criteria, many students participate in testing concepts to evaluate already-existing problems and design solutions.

g. Indicator 7 : Some students have taken the initiative to actively gather data on practicum outcomes, with an average score of 73 and favorable criteria.

h. Indicator 8 : Many students are beginning to be able to construct answers to problems with an average score of 72 and good criteria as a result of the increasing activity of formulating problems, testing ideas, and accumulating information on practicum results.

i. Indicator 9 : With an average score of 73 and good criteria, the majority of students can draw conclusions even when they are incorrect.

Table 5,. displays the findings from the cycle III teaching and learning process observation of student learning activities.

Table 5. Evaluations on Cycle III Student Learning Activities

No.	**Student's Activity Observed**	**Assessment**	
		Score	**Criteria**
1	Notice	89	Very good
2	Discuss	85	Good
3	Ask	87	Good
4	Formulate the problem	72	Good
5	Give an idea	71	Good
6	Testing ideas through practicum	71	Good
7	Gather information on the results of the practicum	73	Good
8	Formulate problem solving	72	Good
9	Draw conclusions	73	Good
	Rate	77	Good

Between cycles II and III, there was a minor improvement in the ability to solve problems. According to the results of the exam on problem-solving skills given at the conclusion of cycle III of learning, students' problem-solving skills were assessed with an average score of 87, and only 87% of them 28 out of 32 were considered to have attained comprehensive problem-solving skills. Cycle II being completed to a classical completeness of 85%, the average value demonstrates an improvement. The achievement of classical completeness can be used as a gauge of how well pupils are now able to solve Colligative Properties-related problems. The Table 6., demonstrates this.

Table 6. Cycle III Student Learning Outcomes Test Scores

No.	Score Total	Mark	
		Number	Letter
1	28	85	B+
2	26	87	A
3	30	87	A
4	28	90	A
5	28	90	A
6	28	69	B
7	23	85	B+
8	33	90	A
9	31	82	B+
10	32	92	A
11	33	90	A
12	31	97	A
13	28	72	B
14	28	72	B
15	30	77	B+
16	28	72	B
17	26	77	B+
18	30	77	B+
19	28	85	B+
20	28	87	A
21	28	87	A
22	23	90	A
23	33	90	A
24	31	79	B+
25	32	84	B+
26	33	90	A
27	31	82	B+
28	28	92	A
29	28	90	A
30	30	97	A
31	33	85	B+
32	31	79	B+
	Rate	85	
	Completed Students	28	
	Completeness Percentage	87,5%	

The following normalized gain calculations show how problem solving skills improved from Cycle II to Cycle III:

$$g = \frac{S_3 - S_2}{S_{maks} - S_2}$$

$$= \frac{85 - 77}{100 - 77}$$

$$= 0{,}35$$

These results show that students' problem-solving abilities have improved, but the progress is still considered to be medium because it is between 0,3 and 0,7. A diagrammatic representation of the outcomes of student problem-solving ability tests from Cycle I through Cycle II and Cycle III is shown in Figure 1.

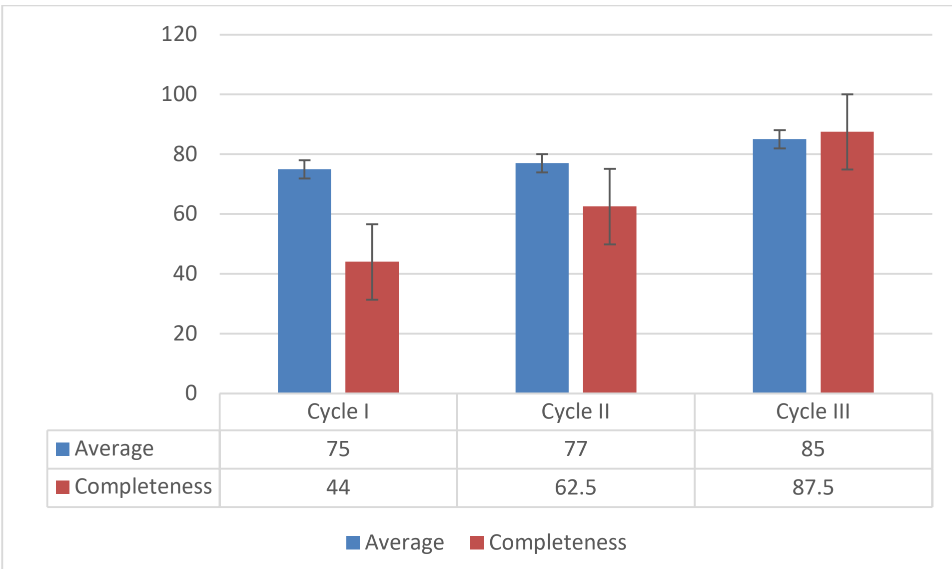

Figure 1. Increasing The thoroughness of one's Problem Based Learning Abilities

The improvement in test scores for students' problem-solving skills demonstrates completeness, which is anticipated to show that cycle III's implementation of the action was successful in raising Colligative Properties problem-solving skills. improving the way PBL actions are carried out, notably through the use of media flash player, guided worksheets, and the sharing of concepts and methods for solving problems amongst successful and unsuccessful students.

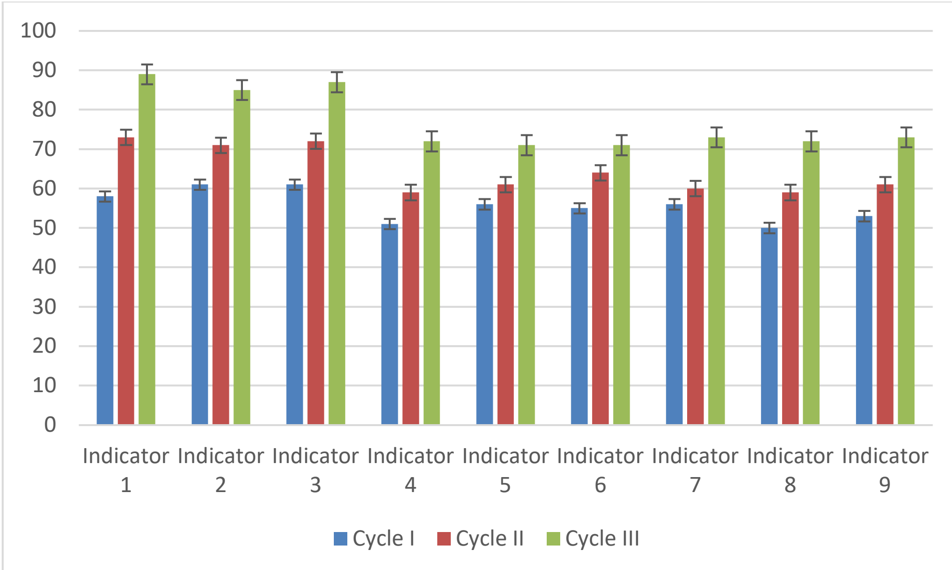

Figure 2. Intensifying Learning Activities for Students

This sequence of corrective measures enhanced the PBL model's application and was very successful in supporting the model's application in enhancing students' problem-solving abilities. Previous study showed that student's who received PBL significantly had better problem solving abilities that student's who received direct learning (Eyceyurt Türk, Gülseda Güngör Seyhan, 2022; Nurhadianti et al., 2023; Türk & Seyhan, 2022).

However, two pupils with Colligative Properties problem-solving ability exam results remained unfinished as of cycle III. Due to the usage of the allotted time for the thermodynamics material during the research, improvements from the two students were made in remedial outside of this study. The research was discontinued in cycle III since it met the success criterion.

CONCLUSIONS AND RECOMMENDATIONS

A. Conclusion

Based on the study's findings, findings, and discussion, several conclusions were drawn, including the following: 1) Students in SMA Negeri 1 Babalan Class XII were better able to solve Colligative Properties problems in the 2021–2022 academic year as a result of the PBL model; and 2) Students were more engaged in Colligative Properties learning activities as a result of the PBL model.

B. Suggestion

According to the results, it is advised to use appropriate learning resources, practice using guided worksheets, and encourage student collaboration so that the PBL paradigm can be used to increase problem-solving skills more effectively.

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