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Strengthening Chemistry Learning Outcomes through Discovery Learning and Laboratory Activities on Colloidal Systems Material

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ABSTRACT

Purpose of the study: This research aims to improve students' chemistry learning outcomes using the discovery method through laboratory activities on the concept of colloidal systems.

Methodology: The method used in this study was classroom action research with a sample of 33 students taught using the discovery method through laboratory activities. The classroom action research consisted of two research cycles, each with stages including planning, implementation, observation, and reflection. The research instruments used were observation sheets, questionnaires, learning outcome tests, and teacher and student interviews.

Main Findings: From the results of this thesis research, it is obtained an overview that this research has achieved the criteria that have become the limit of success indicators shown through the increase in the category of aspects of active student participation in learning in each cycle. Likewise, the learning outcome test saw an increase in the average score in cycle I of 68.09 increasing to 74.81 and no more students received a score below 60.00. Similarly, the results of student interviews responded positively to the learning process using the discovery method through laboratory activities.

Novelty/Originality of this study: This research offers novelty through the integration of discovery learning methods with structured laboratory activities on the concept of colloidal systems to improve student learning outcomes. This approach emphasizes active student engagement through experimentation and problem-solving. These findings complement previous studies by demonstrating the effectiveness of the combination of inquiry learning and practicum in improving conceptual understanding and student participation.

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1. INTRODUCTION

Education plays a crucial role in improving the quality of human resources, particularly in addressing the development of science and technology [1], [2]. One subject that contributes significantly to the development of scientific thinking skills is chemistry [3], [4]. Chemistry learning emphasizes not only mastery of concepts but also understanding processes and their application in everyday life [5], [6]. However, in reality, many students struggle to grasp abstract chemical concepts. This impacts student learning outcomes in chemistry.

One chemistry topic often considered difficult by students is colloidal systems [7]. This concept involves understanding the properties, types, and applications of colloids, which cannot always be directly observed. Furthermore, the lecture-based learning method often makes students less active in the learning process [8], [9]. This lack of student engagement leads to suboptimal conceptual understanding [10], [11]. Therefore, learning strategies are needed to enhance student engagement and understanding.

Discovery learning is one learning approach that can enhance student engagement [12], [13]. In this method, students are encouraged to discover concepts for themselves through observation, experimentation, and analysis [14], [15]. Learning becomes more meaningful because students are directly involved in the process of discovering knowledge [16], [17]. This method also fosters critical thinking and problem-solving skills. Thus, discovery learning has the potential to improve student learning outcomes.

Laboratory activities are an effective tool in chemistry learning. Through practical work, students can directly observe phenomena related to the concepts being studied. These activities help students connect theory with practice, thereby deepening their understanding [18], [19]. Furthermore, laboratories can also enhance students' science process skills [20], [21]. Therefore, integrating the discovery learning method with laboratory activities is highly relevant in chemistry learning [22], [23].

Applying the discovery learning method through laboratory activities provides students with opportunities for active and independent learning [24], [25]. Students not only receive information but also seek and process that information through experiments [26]. This process can foster students' curiosity and motivation to learn [27], [28]. Furthermore, hands-on experience in laboratory activities can strengthen students' retention of the concepts learned, thus making learning more effective and meaningful.

Several previous studies have shown that the use of the discovery learning method can improve student learning outcomes [24], [29]. Similarly, the use of laboratory activities has been shown to enhance understanding of chemical concepts. However, the integrated application of both approaches requires further study, particularly in the topic of colloidal systems. This is crucial to determine the effectiveness of this combined method in improving student learning outcomes. Therefore, this research is relevant.

This research has a strong urgency because students' low conceptual understanding of colloidal systems, which are abstract and difficult to observe directly, remains a problem in chemistry learning. Although various studies have shown that discovery learning models and laboratory activities can improve learning outcomes separately, systematic integration of both in the context of learning colloid concepts is still limited and has not been explored in depth. Therefore, this research is important to address the need for a learning approach that not only improves learning outcomes but also fosters active student engagement and conceptual understanding. The novelty of this research lies in the application of discovery learning combined with structured laboratory activities specifically designed to facilitate the process of discovering colloidal systems concepts through empirical experience. This approach is expected to bridge the gap between abstract concepts and real phenomena, as well as contribute to the development of more effective and scientifically activity-based chemistry learning practices.

Based on this background, this study aims to improve students' chemistry learning outcomes through the discovery method, incorporating laboratory activities on the concept of colloidal systems. This research is expected to provide alternative solutions to address low student learning outcomes. Furthermore, the results are also expected to serve as a reference for teachers in selecting appropriate learning methods. Innovative learning is expected to create a more engaging and effective learning environment. Thus, the quality of chemistry learning can be optimally improved.

2. RESEARCH METHOD

2.1. Type of Research

This research uses a classroom action research approach. The implementation procedure refers to the stages developed by Kurt Lewin. Classroom action research was first introduced by Kurt Lewin, who stated that each research cycle consists of four main stages: planning, action implementation, observation or monitoring, and reflection and evaluation [30], [31]. In its implementation, the research is conducted cyclically, where each cycle includes the stages of action planning, action implementation, action observation, reflection, and conclusion drawing. If the objectives in the first cycle are still not achieved, then improvements or revisions are made in the next cycle to achieve more optimal results.

2.2. Subjects and Participants Involved in the Research

The parties involved in this research included chemistry teachers and eleventh-grade students at Madrasah Aliyah Negeri 12 Jakarta. During the research, the researchers collaborated with the relevant subject teachers. This collaboration was carried out to identify and analyze various problems that arose during the application of the discovery method through laboratory activities. Furthermore, this collaboration also aimed to ensure the learning process ran optimally. Thus, the research could produce more accurate and relevant results to classroom learning conditions [32].

2.3. Data Collection Instruments and Techniques

The data in this study were collected through several techniques, namely questionnaires, interviews, learning observations, and final ability tests. In the learning observation stage, the researcher used a direct observation method, where the recording process was carried out directly on site during the activity [33], [34]. The instrument used in the observation was a rating scale in the form of a checklist. The observation sheet not only contained the objects and aspects being observed but also was equipped with columns indicating the level of achievement of each aspect. The assessment in this study used a five-level scale: very good, good, sufficient, less, and very less. The instrument grid used in this study is as follows:

Table 1. Teacher Interview Grid

No.	Aspects	Number of Items
1.	Teaching preparation	1
2.	Teaching methods and approaches	2
3.	Teaching resources/materials	1
4.	Student learning outcomes	1
5.	Teaching constraints	2
6.	Pedagogical elements in teaching	2
7.	Time allocation	1
	Amount	10

Table 2. Student Interview Grid

No.	Aspects	Number of Items
1.	Student responses to chemistry learning materials	2
2.	Difficulties in learning chemistry	2
3.	Teacher teaching methods	1
4.	Learning resources	1
5.	Student learning outcomes	1
6.	Student responses to the discovery method with laboratory activities	2
	Amount	9

Table 3. Questionnaire Instrument Grid

No.	Aspects	Number of Items
1.	Interest	4
2.	Student Activeness	8
3.	Student willingness to learn using the discovery method through laboratory activities	2
	Amount	14

Table 4. Grid for Observation Sheet of Teacher and Student Activities using the Discovery Method through Laboratory Activities

Aspect	Observed Aspects
Teacher	1. Identify student needs 2. Selecting the introduction to the principles, understanding of concepts and generalization of knowledge 3. Selecting materials and tasks 4. Helps clarify the tasks faced by students and their respective roles 5. Prepare the class and necessary tools 6. Check students' understanding of the problem to be solved 7. Help students with information/data that students need 8. Observe each student in carrying out activities
Student	1. The necessary tools and materials are complete and available 2. Students make discoveries such as taking notes, observing, etc 3. Identify the problem 4. Student-to-student interaction 5. Formulate principles and generalizations of the findings 6. Conduct investigations into problems raised by teachers 7. Complete student worksheets properly

Table 5. Grid of Learning Outcome Test Instruments for Cycle I

No.	Indicator	Cognitive Aspects						Proportion	
		C_1	C_2	C_3	C_4	C_5	C_6	∑	%
1.	Classify mixtures found in the environment into colloidal systems, solutions, and suspensions and summarize their differences.	1	6	4	7	-	-	4	26.67
2.	Explain the components of colloids and the range of colloidal particle diameters.	-	2	-	-	-	-	1	6.67
3.	Classify eight types of colloidal systems based on the dispersed phase and dispersion medium.	5, 14	3	-	-	-	-	3	20.00
4.	Classify colloids found in the environment into several types of colloidal systems.	-	9, 11. 13	8, 10	-	-	-	5	33.33
5.	Describe lyophilic and lyophobic colloids and provide examples of each.	-	15	12	-	-	-	2	13.33
Amount		3	7	4	1	-	-	15	100

Table 6. Grid of Learning Outcome Test Instruments for Cycle II

No.	Indicator	Cognitive Aspects						Proportion	
		C_1	C_2	C_3	C_4	C_5	C_6	∑	%
1.	Understand the properties of colloids (Tyndall effect, Brownian motion, electrophoresis, adsorption, and coagulation) through observation.	1, 2, 9, 14	4, 5, 6, 25	-	23	-	-	9	36
2.	Provide examples of colloid properties.	-	-	3, 8, 16, 21, 22	-	-	-	5	20
3.	Describe and classify various colloid-making processes.	7, 11, 17	12, 20	12, 18	10, 24, 19, 15	-	-	11	44
Amount		7	6	7	5	-	-	25	100

2.4. Data Analysis Techniques

Data analysis and interpretation were conducted to summarize the research findings and assess the validity, consistency, and accuracy of the data obtained. This activity also aimed to answer the various research questions that had been formulated. The results of the data analysis and interpretation were then used as a basis for providing input for improving the research process. In the final stage, these results were used to draw conclusions presented in the research report. Data in this study were obtained through interviews, questionnaires, learning observations, and learning outcome tests, which were then analyzed descriptively [35], [36]. The analysis was conducted on specific groups of individuals to obtain a clear picture of the research results. The assessment of learning outcomes used an authentic assessment approach, which included observation and question and answer sessions, practical implementation, and evaluation through tests. Thus, the data obtained can provide a comprehensive picture of the learning process and outcomes.

3. RESULTS AND DISCUSSION

3.1. Cycle I

The following are the research results from the first cycle which were then analyzed and grouped into: (1) Analysis of the results of processing observation data, (2) Analysis of learning outcomes by looking at the difficulties experienced by students; changes in mastery of the concept of colloidal systems, (3) Analysis of questionnaire data processing, (4) Analysis of interview results conducted after carrying out the learning process in each cycle.

Table 7. Average Observation Results of Cycle I

Aspect	Observed Aspects	Evaluation	Keterangan
Teacher	1. Identify student needs	4	Good
	2. Selecting the introduction to the principles, understanding of concepts and generalization of knowledge	3	Medium
	3. Selecting materials and tasks	3	Medium
	4. Helps clarify the tasks faced by students and their respective roles	3	Medium
	5. Prepare the class and necessary tools	4	Good
	6. Check students' understanding of the problem to be solved	2	Less
	7. Help students with information/data that students need	3	Medium
	8. Observe each student in carrying out activities	2	Less
	Average	3	Medium
Student	1. The necessary tools and materials are complete and available	4	Good
	2. Students make discoveries such as taking notes, observing, etc.	3	Medium
	3. Identify the problem	3	Sedang
	4. Student-to-student interaction	3	Medium
	5. Formulate principles and generalizations of the findings	2	Less
	6. Conduct investigations into problems raised by teachers	3	Medium
	7. Complete student worksheets properly	3	Medium
	Average	3	Medium

Based on Table 7, it can be seen that there are still several areas for improvement in the teacher aspect, such as selecting teaching materials and assignments, and developing preliminary activities related to the principles and concepts to be learned. These improvements are necessary to ensure the learning process is effective and time-efficient. However, in Cycle I, time management was still not implemented proportionally. Furthermore, teachers need to clarify the division of tasks and roles for each student within the group, and provide motivation so that all students can actively participate in the discovery process. Teacher supervision also needs to be improved to ensure that students' understanding of problem-solving is properly monitored.

Meanwhile, in the student aspect, which encompasses seven indicators, the average score was 3, which is in the moderate category and does not meet the success indicator. This condition is evident in students' suboptimal abilities in conducting discoveries and identifying problems. Interaction between students was also not optimal, due to a lack of clarity regarding the tasks and roles of each group member. As a result, some students tended to rely on their group mates. Furthermore, some students were still less active in recording and observing the discovery process.

Table 8. Average Results of Student Questionnaires in Cycle I

No	Indicators	Average
1.	Interest	59.08%
2.	Student Activity	73.10%
3.	Student willingness to learn using the discovery method through laboratory activities	77.77%

Based on the table above, for the first cycle, the interest indicator showed that students' interest in paying attention and studying chemistry was still low, at 59.08%. Meanwhile, the student activity indicator showed a fairly good level of engagement. This is supported by the percentage of students who answered yes to the statement, which was 73.10%. Furthermore, the student willingness to learn using the discovery method through laboratory activities indicator demonstrated high student enthusiasm for the learning method used. Thus, students responded positively to the learning method taught at the school.

Based on the test results administered in cycle I, the average student learning outcome was 68.09, indicating that student learning outcomes based on cognitive abilities had not yet achieved the success indicator. The student learning outcome test scores for cycle I are shown in the following table:

Table 9. Frequency Distribution of Learning Outcome Test Scores for Cycle I

Value Range	Absolute Frequency	Relative Frequency
53 – 57	1	3.03%
58 – 62	8	24.24%
63 - 67	11	33.33%
68 – 72	-	-
73 – 77	9	27.27%
78 – 82	4	12.12%
Amount	33	100%

Based on Table 9 above, it can be seen that one student still scored below the Minimum Completion Criteria, which is less than 60. Furthermore, the average class score, as listed in the appendix, was 68.09. This score indicates that student learning outcomes in Cycle I did not meet the established success indicator, which is greater than 70. Therefore, this research needs to be continued to the next cycle to achieve the desired results.

The researcher conducted interviews with 11th grade science students to gather their responses to the learning they had undertaken thus far. The following data were obtained from these interviews:

Table 10. Student Interview Results Data from Cycle I

No.	Question	Interview Results Description
1.	After taking a chemistry lesson with practical activities, were you satisfied with the method used by the teacher?	According to students, chemistry lessons were quite enjoyable, as they had previously only received lectures.
2.	Did learning using the discovery method through laboratory activities make you more active in your learning, or did it make you bored? Explain why.	According to students, learning chemistry using the discovery learning method made learning more active, especially with the inclusion of practical activities that prevented boredom.
3.	Did carrying out laboratory activities make you more curious or not? If yes, explain why. If no, explain why!	Students reported a high level of curiosity about the material taught through the practicals. This was driven by their curiosity about what they observed.
4.	In your opinion, was the teacher's explanation clear enough?	According to students, the explanations given were quite clear.
5.	Did the teacher provide direction and guidance to the students?	Teachers did provide direction and guidance to students, but only to those who asked questions.
6.	In your opinion, was the teacher able to create a conducive learning environment?	According to students, teachers still did not create a conducive learning environment, as the classroom atmosphere was still noisy.

Based on the interview results, it can be concluded that students responded positively and were quite enthusiastic about the applied learning method. This was because they had previously been more accustomed to learning chemistry through lectures. The implementation of laboratory activities enabled students to become more active in the learning process, particularly through practical activities, which made learning more engaging and less boring. Furthermore, the hands-on experience students gained helped them understand the abstract concepts contained in textbooks. However, the laboratory conditions were still not entirely conducive due to the crowded and noisy atmosphere. Based on this analysis, the researcher and subject teachers attempted to improve direction and guidance for students. This was done to ensure students had a clearer understanding of the learning activities. Furthermore, efforts were focused on creating a more orderly and conducive laboratory environment. This is expected to lead to a more effective and optimal learning process.

After observing student learning activities during the learning process, a reflection was conducted. The reflection aimed to identify positive aspects and problems that emerged in the first cycle, which will be addressed in the second cycle by providing specific treatments. The problems identified in the implementation of this first cycle and the alternative treatments that will be applied in the next cycle are:

Table 11. Reflection of Cycle I Actions

Aspect	Activities / Actions observed	Action Solution
Teacher	1. Identify student needs	– Improve student approaches and supervision to determine their understanding of colloidal systems.
	2. Selecting the preliminary understanding of principles, concepts and generalizations of knowledge.	– Improve lesson plans and add materials to student worksheets with easy-to-understand presentations.
	3. Select materials and assignments.	– Improve material selection and student assignments in identifying problems and other steps.
	4. Help clarify the tasks faced by students and their respective roles.	– Motivating students to actively participate in learning activities.
	5. Prepare the class and necessary tools.	– Assigning clear assignments to each student in each group.
	6. Check students' understanding of the problem to be solved.	– No problems were encountered because the teacher prepared the class and provided the necessary equipment well.

	7. Help students with the information/data that students need. 8. Observe each student in carrying out activities.	– Assigning groups with attention to student achievement and activity levels. – Supervise each group evenly to ensure they are actively engaged in discovery activities. – Go around the class and check the assignments and activities of each student in a group to prevent reliance on others.
Student	1. The necessary tools and materials are complete and available.	– The tools and materials needed are complete and available, just provide motivation to always bring the materials needed for the laboratory.
	2. Students make discoveries such as taking notes, observing, etc.	– Supervise each group evenly to ensure they are actively engaged in discovery activities. – Always remind students not to rely on their peers' notes and to foster curiosity about the problems presented.
	3. Identify the problem.	– Assist and guide students with information and data. – Provide motivation and direction to students.
	4. Student-to-student interaction.	– Motivate students to actively participate in discovery activities. – Supervise each group evenly to ensure they actively participate in classroom interactions/discussions.
	5. Formulate principles and generalizations of the findings.	– Help students by providing direction and guidance – Provide opportunities for students to convey conclusions from their findings and encourage students to speak in front of the class.
	6. Conduct investigations into problems raised by teachers.	– Supervise each group evenly to ensure they are actively investigating the problem. – Check student understanding and assist students with the necessary data.
	7. Complete the student worksheets properly.	– Improve student worksheets by presenting the material in an easy-to-understand manner. – Assign students to read the Student Worksheets before completing them. – Always remind students to complete the worksheets thoroughly, not to rely solely on their peers' answers and to believe in their own abilities. – Provide guidance to students experiencing difficulties with the Student Worksheets.

3.2. Cycle II

In the implementation of teaching and learning activities in cycle II, observations are the same as those carried out in cycle I. The observations carried out are observations of teacher and student activities in carrying out the stages of discovery activities through laboratory activities by carrying out a checklist on the available observation sheet. The observation sheet consists of 2 aspects that are assessed, namely: 1) Teacher aspects, including 8 observed aspects; and 2) Student aspects, consisting of 7 observed aspects. The following are the results of research from the first cycle consisting of observation sheets, student learning outcome data, questionnaire results and interview results.

Table 12. Average Observation Results of Cycle II

Aspect	Observed Aspects	Evaluation	Information
Teacher	1. Identify student needs	4	Good
	2. Selecting the introduction to the principles, understanding of concepts and generalization of knowledge	4	Good
	3. Selecting materials and tasks	4	Good
	4. Helps clarify the tasks faced by students and their respective roles	4	Good
	5. Prepare the class and necessary tools	5	Very Good
	6. Check students' understanding of the problem to be solved	4	Good
	7. Help students with information/data that students need	4	Good
	8. Observe each student in carrying out activities	4	Good

Average		4	Good
Student	1. The necessary tools and materials are complete and available	4	Good
	2. Students make discoveries such as taking notes, observing, etc	5	Very Good
	3. Identify the problem	4	Good
	4. Student-to-student interaction	4	Good
	5. Formulate principles and generalizations of the findings	4	Good
	6. Conduct investigations into problems raised by teachers	4	Good
	7. Complete student worksheets properly	5	Very Good
Average		4	Good

Based on the table, it can be seen that in the second cycle, there was an average improvement in both teacher and student aspects compared to the first cycle. The teacher aspect observed included eight indicators, while the student aspect consisted of seven indicators. Improvements in the teacher aspect were particularly evident in the preliminary stage, such as identifying student needs and selecting principles, materials, and learning tasks. These improvements resulted in more effective and efficient use of time. Thus, learning in the second cycle became more focused.

Furthermore, improvements were evident in the teacher's ability to clarify student tasks and the roles of each group member. The teacher also performed more effectively in monitoring and checking students' understanding of the assigned problems. This resulted in increased student engagement and participation in implementing the discovery steps compared to the first cycle. This positive impact was also evident in student aspects, such as increased interaction between students, involvement in the discovery process, and the ability to investigate problems. Students also showed improvement in completing worksheets and in formulating principles and generalizations from the findings. Therefore, based on the results of activity observations, it can be concluded that student activity in the second cycle met the success indicators in the good category.

Table 13. Average Results of Student Questionnaires in Cycle II

No	Indicators	Average
1.	Interest	73.47%
2.	Student Activity	81.81%
3.	Student willingness to learn using the discovery method through laboratory activities	82.82%

The learning outcome test scores in cycle II with a discussion on the properties of colloids and the manufacture of colloids obtained the following data:

TTable 14. Frequency Distribution of Learning Outcome Test Scores for Cycle II

Value Range	Absolute Frequency	Relative Frequency
60 -64	1	3.03%
65 – 69	3	9.09%
70 – 74	18	54.54%
75 – 79	-	-
70 – 84	9	27.27%
85 - 89	2	6.06%
Amount	33	100%

Based on the table above, it can be seen that no students received scores below 5. The average class score in Cycle II increased from 68.09 to 74.81 (calculations are provided in Appendix 15). Therefore, this study was deemed sufficient for Cycle II and will not be continued to the next cycle.

In this study, the researcher also conducted interviews with some 11th grade science students to determine their responses to the learning process using the discovery method through laboratory activities in both the first and second cycles. Interviews were conducted at the end of Cycle II after conducting the learning outcome test and completing the questionnaire.

Table 15. Student Interview Results Data from Cycle II

No.	Question	Interview Results Description
1.	After taking a chemistry lesson with practical activities, were you satisfied with the method used by the teacher?	After participating in chemistry lessons with practical activities, students expressed their satisfaction with the practical activities and the teacher's methods. They gained a deeper understanding of the chemistry material compared to lectures. Because students were directly involved in

		the practical activities, their retention of the material was more lasting.
2.	Did learning using the discovery method through laboratory activities make you more active in your learning, or did it make you bored? Explain why.	Students reported that their chemistry lessons were more active because they focused solely on the problems posed by the teacher and attempted to find the answers, eliminating unrelated activities such as chatting with friends.
3.	Did carrying out laboratory activities make you more curious or not? If yes, explain why. If no, explain why!	During the discovery learning process through laboratory activities, students' curiosity about the results of what they observed in the practical activities arose.
4.	In your opinion, was the teacher's explanation clear enough?	According to students, the explanations were clear enough.
5.	Did the teacher provide direction and guidance to the students?	The teacher provided direction and guidance to all students.
6.	In your opinion, was the teacher able to create a conducive learning environment?	According to students, the teacher was able to create a conducive learning environment, as the classroom atmosphere was quiet and the teacher constantly circulated to observe students.

From the interview results above, it can be concluded that students responded positively to the method used and that it prevented boredom. The learning environment, which utilized a laboratory approach, created enjoyment, stimulated curiosity, and helped students understand concepts beyond simply reading a textbook or listening to a teacher's explanation.

Based on the analysis and evaluation of data from Cycle II, it emerged that the application of the discovery method through laboratory activities was effective in learning chemistry, focusing on the concept of colloidal systems. This was evident in the teacher's increased attention to all students, rather than focusing solely on a select few. Furthermore, student motivation also showed a significant improvement [37]. Students became more confident, expressed their opinions, were more focused, and actively participated in the learning process.

Student activity in carrying out the discovery steps also improved compared to the first cycle. This was evident in students' abilities to make discoveries, identify problems, interact with fellow students, formulate principles and generalizations, and investigate problems presented by the teacher. These improvements met the success indicators, which were categorized as good. Furthermore, student learning outcomes also met the criteria set as success indicators [38], [39]. Thus, deficiencies identified in the first cycle were addressed and refined in the second cycle. Based on the research conducted, several important findings were obtained. In cycle I, student activity in implementing the discovery steps still needed improvement and did not meet the success indicators. Observations showed that students were still less than optimal in conducting discoveries, such as recording and observing, identifying problems, interacting with fellow students, formulating principles and generalizations, and conducting investigations into the given problems. This condition was influenced by the teacher's inadequate role in providing comprehensive guidance and supervision. Teachers did not fully help clarify students' tasks and roles, check understanding, and provide necessary information during the activities.

In Cycle II, there was a significant increase in student activity in learning using the discovery learning method through laboratory activities. Students demonstrated a more serious, calm, and focused attitude during the learning process [40]. Interaction between students also improved, particularly in terms of group work and clearer assignments. This was supported by the teacher's more optimal role in supervising and providing direction. As a result, students were better able to follow the steps of the discovery learning activities effectively. This improvement was evident in observation results, which showed a change in the category from moderate in Cycle I to good in Cycle II.

Furthermore, the results of learning tests administered at the end of each cycle indicated an improvement in students' cognitive abilities. In Cycle I, the average class score was 68.09, while in Cycle II, it increased to 74.81. This improvement indicates that the applied learning improved students' learning outcomes on the concept of colloidal systems. Thus, the discovery learning method through laboratory activities had a positive impact on student learning outcomes.

Questionnaires and interviews conducted with students also showed a positive response from Cycle I to Cycle II. Students felt more enthusiastic and motivated in participating in learning. This was due to the use of the discovery learning method, which encouraged students to be more active in the learning process. The practical activities also provided a fun learning experience and stimulated students' curiosity about the material being studied [41], [42]. This made learning more engaging and meaningful for them.

Overall, the results of this study demonstrate that the application of the discovery learning method can improve student activity and learning outcomes. Learning becomes student-centered because they are given the opportunity to discover concepts for themselves through active mental processes. This process encourages increased curiosity and a deeper understanding of the material. These findings align with the advantages of the discovery learning method, which can increase student motivation and engagement in learning. Therefore, this method is effective in improving student chemistry learning outcomes.

This research has significant implications for chemistry teaching practices, particularly in enhancing students' active engagement and conceptual understanding through the integration of discovery learning and laboratory activities. The results indicate that learning that emphasizes the discovery process and hands-on experience can help students construct knowledge more meaningfully, increase learning motivation, and reduce reliance on lecture methods. Practical implications: Chemistry teachers can utilize this approach as an alternative, more effective learning strategy for abstract materials such as colloidal systems, while simultaneously developing students' science process skills. However, this research has several limitations, including the limited number of subjects in one class, which limits the generalizability of the results. The classroom action research design did not involve a control group, making it impossible to compare the effects of the methods experimentally. Furthermore, the relatively short duration of the study and its focus on a single learning topic also limit the ability to assess the sustainability of the impact on students' conceptual understanding. Therefore, further research is recommended to employ an experimental design with a broader sample size and to examine the applicability of this approach to other chemistry materials to obtain a more comprehensive picture.

4. CONCLUSION

Based on the data analysis and discussion presented, it can be concluded that chemistry learning by applying the discovery method through laboratory activities is able to improve student learning outcomes in the concept of colloidal systems. This is supported by observation data, questionnaires, and interviews which show that the implementation of learning in cycle II is better than cycle I. This improvement occurred due to improvements in actions taken by the teacher, such as more effective time management, increased supervision of all students, and ensuring that each student understands the objectives and procedures of the activity. In addition, the teacher also provided more optimal motivation and divided tasks evenly within the group, so that all students were actively involved in the problem-solving process and discovery activities. The improvement in student learning outcomes is also evident from the average score obtained, which was from 68.09 in cycle I to 74.81 in cycle II. This indicates a significant development in students' understanding of the material being studied. Thus, it can be concluded that the use of the discovery method through laboratory activities is effective in improving students' chemistry learning outcomes. The results obtained have also met the criteria for success indicators that have been set in the study. Future research is recommended to use an experimental or quasi-experimental design involving a control group and a larger sample size to more comprehensively test the effectiveness of the approach. Furthermore, the study could be expanded to other chemistry topics and examine its impact on students' long-term conceptual understanding and higher-order thinking skills.

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AUTHOR CONTRIBUTIONS

Conceptualization, H. and A.A.; Methodology, H.; Software, H.; Validation, H. and A.A.; Formal Analysis, H.; Investigation, H.; Resources, H.; Data Curation, H.; Writing – Original Draft Preparation, H.; Writing – Review & Editing, A.A.; Visualization, H.; Supervision, A.A.; Project Administration, H.; Funding Acquisition, A.A.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

Not applicable.

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