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Improving learning outcomes through discovery learning on the human respiratory system material

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ABSTRACT

Based on the results of observations at Madrasah Aliyah Negeri (State Islamic Senior High School) 1 Palembang, it was found that there were problems in learning biology; namely, the daily test scores for class XI science 2, semester 1 for the 2021/2022 around 30% of students have scored above the minimum completeness criteria (MCC) and the learning outcomes of school year 2020/2021 it shows only 29% or nine students out of 31 students achieve scores above the MCC. This research aims to improve student's learning outcomes in class XI science 2 using the discovery learning model. This type of research is called classroom action research (CAR) and consists of two cycles. The results showed that applying the discovery learning model can improve students' learning outcomes. The learning outcomes of the knowledge domain in the first cycle obtained a percentage of students' completeness of 53.33% (average value was 68). In contrast, in the second cycle, there was an increase in students' completeness of 83.33% (average value was 81). Applying the discovery learning model implemented at Madrasah Aliyah Negeri 1 Palembang, can improve learning outcomes. The increased learning outcomes were accompanied by increased student activity in asking, answering, and discussing. The percentage of learning outcomes in the first cycle of cognitive aspects from 53.33% of students who obtained a score above the MCC with an average score of 68 increased by 83.33% with an average score of 81 in Cycle II.

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1. INTRODUCTION

School is a place to learn various sciences and shape students' character. Learning in schools should be fun; thus, the information obtained by students can be easily conveyed. However, the problems currently faced in the learning process in schools are very complex, especially in implementing learning, starting from motivation and learning outcomes, which still need improvement. This is the focus of mistakes on education providers, especially teachers [1]. Teachers play an essential role in the classroom because most of the success factors in learning depend on the teacher in transferring knowledge to students, especially in providing biology material [2]. Biology is a science that is not only limited to mastery of concepts but also a process of discovering knowledge by oneself to increase understanding [3]. Teachers provide knowledge not only in the form of

delivering information (material) but also need to see the improvement of students in developing their abilities [4]. In essence, learning biology's purpose includes assessing cognitive aspects, affective aspects (attitudes), and an orientation towards learning evaluation [5].

Researchers found several obstacles in the biology learning process based on observations at Madrasah Aliyah Negeri (State Islamic Senior High School) 1 Palembang in class XI science 2. Regarding daily test scores for class XI science 2, semester 1 for the 2021/2022 academic year, about 30% of students got scores above the minimum completeness criteria (MCC) and the learning outcomes for the 2020/2021 academic year, only 29% or about 9 out of 31 of the total students achieved scores above the MCC, especially in the respiratory system material low learning outcomes caused by several factors, among others. First, the teacher was still the center of learning activities; thus, the active involvement of students has yet to be seen. Second, teachers have yet to use the learning model. The 2013 curriculum mandated them. Thus, students tend to be bored when receiving lessons; they talk a lot and need to be more curious about lessons. The teacher only applies the lecture and question and answer method when learning in class. The weaknesses of this method include low student activity in class, students' need for more focus on receiving lessons, and low levels of interest in learning [6]. Learning activities in the 4.0 era require students to be more active, think critically and collaborate [7]. According to González-pérez and Ramírez-montoya [8], 21st-century education requires students to be skilled at creative thinking, solving problems, communicating and critical thinking. Third, the teaching materials used did not vary because of the dominant use of publishers' printed books. This makes students less interested in reading and need help understanding the material [9]. The accumulation of these three problems impacted the test scores that had yet to reach the specified MCC of 70.

Efforts to overcome the problems faced above are that teachers must find ways to make students diligent and enthusiastic about learning. One of the aims of implementing interesting learning is to stimulate students to increase their curiosity and active involvement in the classroom by implementing appropriate learning models based on the 2013 curriculum reference. The choice of learning model must adapt to the student's conditions. Thus, the applied model can provide benefits to achieve learning objectives [10]. The respiratory system material is one of the abstract biological materials because most of it is just a concept. Thus, students need help understanding [11]. This material has six indicators closely related to everyday life. Therefore, it is important to understand them. The six indicators include the location and structure of the respiratory organs in humans, the function of the respiratory organs in humans, the mechanism of respiration in humans, the exchange of oxygen and carbon dioxide, diseases of the respiratory system and the effect of smoking on respiratory health in humans. The discovery learning model was selected because it can train students to find and understand the concepts of the material being studied for themselves; therefore, it will improve their memory and understanding and increase student activity in the learning process [12]. Discovery learning foster authentic connections between students and teachers, leading to improved learning outcomes and reduced prejudice [13]. Discovery learning, by promoting student autonomy and inquiry, can counteract these dynamics, allowing students to take ownership of their learning. This approach not only enhances understanding of scientific concepts but also encourages collaboration and communication among peers. This research aims to improve and enhance the learning process in the classroom. One of the learning models recommended by the 2013 curriculum is the discovery learning model. The learning steps in this model, such as providing stimulus, identifying problems or issues, collecting data, processing data, proving and being able to conclude, can encourage students to discover and understand the concept. Based on research conducted by Inan *et al.* [14], implementing the discovery learning model in the classroom makes students more active and participatory so that students remember and understand the material more easily. In line with research by Sinambela *et al.* [15], the discovery learning model can make students better understand science concepts in junior high school. Classroom dynamics can affect student engagement and approval in science learning [16]. There is a gap between expectations and reality [17], when applied in the classroom, the discovery learning model can improve learning outcomes, especially in nervous system material. Thus, a teacher needs to carry out a learning process that is not centered on the teacher but the students. Completeness in MCC is a demand for the 2013 curriculum using learning models. The solution to these problems is that teachers must conduct classroom action research (CAR) using a discovery learning model applied to the material of the human respiratory system.

2. METHOD

This research was carried out at Madrasah Aliyah Negeri 1 Palembang in January 2022. The research subjects were students of class XI science 2 in the even semester of the 2021/2022 academic year, consisting of 14 male and 16 female students. The CAR procedure has four steps [18]: planning, action, observation and reflection (one cycle). After reflection, you can continue to the next cycle until an increase in learning is obtained. The data obtained in this research is from students' cognitive test results to assess the improvement

of learning outcomes. The data sources used are students' test scores in class XI science 2 and documents in the form of learning tools, photos and recordings of activities.

Data analysis in this CAR used quantitative analysis. Results quantitative data analysis was obtained from the tests carried out. Data analysis was carried out to calculate grades and class averages using the formula from Mohajan [19]:

$$\text{Score} = \frac{Total\ Score\ \ Obtained}{Maksimal\ Score}\ s\ 100$$

The class average is calculated using the formula:

$$\text{Mx} = \frac{\sum X}{N}$$

Note: Mx is mean (average) class, $\sum X$ is the total number of student scores, and n is the total number of students.

Calculating classical completeness using the formula from [20]:

$$\text{Classical learning completeness} = \frac{Classical\ learning\ completeness}{Total\ number\ of\ students} \times 100\%$$

Individual learning mastery is obtained if students get a score of 70. Classical mastery is obtained if 70% of the students reach a value of 70. Before entering the first cycle, the initial step begins with pre-research activities that determine the state of learning in the classroom, and then the planning of the first cycle is carried out.

2.1. Cycle I

The research procedure in CAR has its research design. There are four steps in CAR in one cycle [21]: planning, action, observation and reflection. After reflection, it can be continued to the next cycle until learning outcomes are increased.

a. Planning
   At this stage, the teacher compiles integrated learning devices. The syntax is in accordance with the discovery learning model, including lesson plans, student worksheets, and questions. Furthermore, the learning tools must be validated with three validators, and the learning media must be prepared.
b. Action
   Teachers implement learning using learning tools that have been validated and integrated according to the discovery learning model. The implementation of the Cycle I, the first meeting was held on Monday, 10 January 2022, at 09.00-10.00 AM; the second meeting on Tuesday, 11 January 2022, at 10.30-11.30 AM and the third meeting on Monday, 17 January 2022, at 09.00-10.00 AM. The implementation of learning was recorded using a mobile phone camera and photographed as documentation material. The division of groups based on the heterogeneity of academic grades and gender aims so that students can work well together when working on the assigned tasks. Test activities will be carried out at the last meeting of the first cycle after the breathing mechanism in humans.
c. Observation
   Observations are carried out by observers (peers) during the learning process. The observation sheet intended for teachers is prepared based on the stages of the discovery learning model, the distribution of time in class, and the classroom atmosphere during learning. The purpose of observations is to help teachers observe learning activities using the discovery learning model. Assessment of teacher activities based on emerging indicators. Each indicator that appears is given a score of 1, and that does not appear is given a score of 0.
d. Reflection
   The teacher evaluates student learning outcomes and analyzes the results of observations with observers. Observations are conducted to see whether implementing the learning process using the discovery learning model successfully improved student learning in the classroom. If the implementation of the Cycle I still needs to be successful, it can be continued to the next cycle to determine an improvement plan until the learning objectives can be achieved.

2.2. Cycle II

a. Planning
   In Cycle II, the teacher prepared lesson plans, student worksheets, and questions integrated according to the discovery learning model. Three validators validated learning tools. Teachers prepare learning media and observation sheets to observe teacher activities during the learning process.

b. Action
   Teachers carried out the learning process using devices that had been validated and integrated according to the discovery learning. The material presented in Cycle II, regarding the mechanism of oxygen and carbon dioxide exchange, was presented for the first meeting, respiratory system diseases were discussed in the second meeting, and the effect of smoking on human health was discussed in the third meeting. The first meeting of Cycle II was held on Tuesday, 18 January 2022, at 10.30-11.30 AM; the second meeting on Monday, 24 January 2022, at 09.00-10.00 AM and the third meeting on Tuesday, 25 January 2022, at 10.30-11.30 AM.
c. Observation
   The teacher is assisted by a peer who acts as an observer to observe the learning process and document through photos and videos using a mobile phone camera. Teacher activities in the teaching and learning process in the classroom are observed by observers based on the observation sheet that has been prepared. After this activity, a discussion was held to see which parts needed to be improved.
d. Reflection
   Teachers and observers carry out reflections to evaluate and analyze the results of observations in Cycle II. The teacher concludes the activities carried out in Cycle II. If the results are good, the next cycle does not need to be carried out, but if the results are not good, they will be continued to the next cycle.

3. RESULTS AND DISCUSSION

The pre-research was carried out as an observation to find out the problems in class XI science 2 at Madrasah Aliyah Negeri 1 Palembang. Based on observations made in August 2021, teachers still taught monotonously during the limited face-to-face learning process using lecture and question-answer methods. Thus, students become lazy and inactive in class [22]. It was also found that there was no feedback when the teacher asked questions, and many students remained silent. Based on the daily test results, only 30% get a complete score with the minimum standard of completeness criteria, which is 70 for class XI biology subjects.

3.1. Cycle I

The Cycle I implementation research results include planning preparation, implementation, observation or monitoring and reflection or follow-up at the planning stage. At the planning stage, the researchers compiled learning tools that have been integrated according to the discovery learning model, including lesson plans for basic competencies 3.8.1-3.8.3, student worksheets regarding the material of the location and structure of the human respiratory organs, the function of the respiratory organs in humans and the mechanism of breathing in humans, as well as multiple choice questions totalling 20 items as test instruments that will be carried out at the third meeting. The learning tools were validated and assisted by three validators from biology teachers and lectures the implementation of a Cycle I was carried out for three meetings. The implementation stage of the action used learning tools that were integrated according to the discovery learning model. The observation stage was carried out simultaneously with the learning process. The teacher directs students to find their knowledge. Teachers also form groups to work together to solve problems. The teacher was assisted by an observer named NH to observe the teacher's activities in implementing the discovery learning model. The results obtained from observing teacher and student activities, as well as the results of tests carried out in Cycle I, can be explained as follows:

3.1.1. Results of teacher activity observation

A comparison of the results of implementing the discovery learning model after being observed by colleagues can be seen in Table 1. In Cycle I, the average value of teacher teaching activities increased from meetings 1, 2, and 3. Teacher activities that significantly increased were regarding time management, questioning techniques teachers, and managing classroom situations.

Based on Table 1, the % of teacher activity in the learning process is 87.37% in the very good category. However, teachers skip several steps that need to be considered, such as unending time management in the learning process and forgetting memory activities at the end. This can be seen from the results of the first meeting. The closing activity was only achieved at 66.67%, the second meeting was 100%, and the third meeting was 66.67%, averaging 77.78%. Time management, teacher questioning techniques and classroom atmosphere only achieved 50% at the first meeting, 50% at the second and 100% at the third, with an average of 66.67%. Therefore, improving the learning process in the next cycle is necessary.

3.1.2. Results of students' learning outcomes

The learning outcomes of class XI science 2 students during the learning process in the first cycle can be seen in Figure 1. Based on Figure 1, the student's written test results in Cycle I obtained a range of values from

the smallest value, namely 40 and the most significant score, 95. The frequency of scores obtained by the most students was 50-59, which is as many as nine people, and the frequency of the lowest value obtained by students was 40-49, as many as two people. Fourteen students obtained a score of <70, and 16 people obtained a score of ≥70. The percentage of complete learning outcomes in the knowledge aspect can be explained in Figure 2.

Table 1. Results of teacher activity observation Cycle 1

No.	Teacher Activities	Meet 1 (%)	Meet 2 (%)	Meet 3 (%)	Average (%)
1	Preliminary	100	100	100	100
2	Core activities:				
	– Stimulation	100	100	100	100
	– Problem statements	100	100	100	100
	– Data collection	100	100	100	100
	– Data processing	100	100	100	100
	– Verification	100	100	100	100
	– Generalization	50	100	100	83.33
3	Closing	66.67	100	66.67	77.78
4	Time management	50	50	100	67.67
5	Teacher questioning technique	50	50	100	67.67
6	Class situation	50	50	100	67.67
	Average	78.79	86.36	96.97	87.37

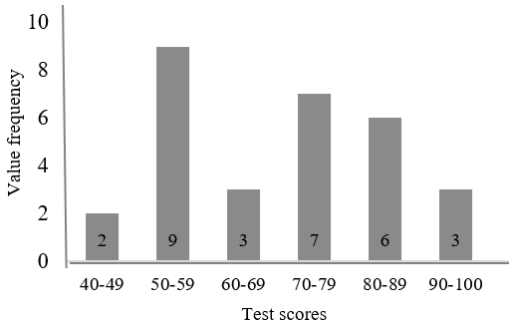

Figure 1. The results of the written test Cycle 1

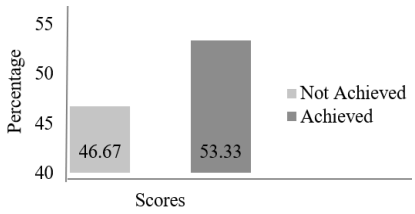

Figure 2. Percentage of completeness Cycle 1

Based on the student's learning outcomes in the first cycle, it can be stated that only 53.33% of students have reached the MCC, while those who have yet to reach the MCC are 46.67%. This needs to follow the achievement of indicators of success in research actions. These results show that students still have difficulty answering questions given by the teacher because of the student's lack of preparation in facing the test. The unpreparedness of the students to face the given test has an impact on their learning outcomes. In line with the opinion of [22], the student's lack of preparation for the test causes the scores they obtain to be below the MCC.

The implementation of the learning process in Cycle I by applying the discovery learning model has run smoothly, although deficiencies still need to be corrected. At the stimulus stage, the teacher provides stimulation, which is still an image display from PowerPoint. Thus, at the problem identification stage, students still need clarification and confidence in expressing their opinions; thus, some students still have yet to participate actively. This is because the teacher needs to explain the steps of the discovery learning model in detail, and students need to be used to identifying problems [21]. At the data collection and processing stage, many students were still working on student worksheets individually, so collaboration between groups needed to be better established. Students are still undisciplined in completing student worksheets, so the results of

training in student worksheets are not optimal. Some students still plagiarize the work of other group friends, so cooperation within their group and tolerance still need to be improved. When presenting the results of the student worksheets, some students still needed to be more active in responding or asking questions; many of them were embarrassed to express their opinions.

The constraints found in the implementation of learning in Cycle I affected students' learning outcomes so that only 53.33% reached the MCC. This is because students had not been able to work well together in the learning process; group discussion activities had not run optimally because students worked more alone while others only copied the work of their friends; thus, the completion of tasks on student worksheets is not timely, and students do not master the problems or questions contained in the student worksheets. In addition, the unpreparedness of students to face the given test impacts learning outcomes. In line with the opinion of [23], the student's lack of preparation for the test causes their scores to be below the MCC. The results of research support this [24]; students need to use their time better in group discussions. Thus, the tasks given are carried out partially, and the learning outcomes could be higher.

Based on the results of reflection in Cycle I regarding the learning outcomes of students' cognitive aspects that still need to achieve indicators of success in research activities, it is necessary to continue to Cycle II to improve the weaknesses found in learning the first cycle. Teachers should focus more on guiding students in expressing opinions and asking questions, therefore at the stimulus stage, students are usually given an image display to elicit their opinions so that in the second cycle, they will be given a video display to increase their concentration and be able to participate in the learning process actively. The teacher reprimands if there are still students who chat during the discussion. The teacher created a different group from the first cycle to overcome this. Teachers can assess group work results to raise their enthusiasm in class.

3.2. Cycle II

The second cycle was implemented by considering the results of the reflection in the first cycle. At this stage, the teacher again prepared learning tools such as the revised lesson plans for basic competencies of 3.8.4-3.8.6. The lesson plans were revised in the main activity section when the group division was carried out at the beginning before the stimulation stage and the addition of videos at the stimulation stage. Student worksheets were on the exchange of oxygen and carbon dioxide in the human respiratory system, diseases of the respiratory system and the effects of smoking on human health, a written test in the form of 20 multiple-choice and observation sheets for teachers and students. The implementation of observations in the second cycle was carried out simultaneously with the learning process. The observer observed the activities of the teacher when she taught by using the discovery learning model.

The existence of obstacles in the first cycle required improvements to improve the learning process. The teacher warned students who only copied the work of their friends to participate in discussions actively and reminded them to understand the problems in the student worksheets and prepare themselves when the learning outcomes test is carried out. In the second cycle, the teacher improves learning by providing stimuli through pictures, questions, videos, and simple practicums. The teacher forms a new group and awards the best group predicate. The teacher provides student worksheets as student work material PowerPoint and video as reference.

3.2.1. Results of teacher activity observation

Based on the results of observations of teacher activities can be seen in (Table 2). Table 2 consists of three meetings on teacher teaching activities. Learning activities consist of introduction, core activities, closing, time management, questioning techniques, and classroom situations. Table 2 shows that the learning activities carried out by the teacher using the discovery learning model had been fully implemented with the very good category and achieved maximally.

Table 2. Results of teacher activity observation in Cycle II

No	Teacher activities	Meet 1 (%)	Meet 2 (%)	Meet 3 (%)	Average (%)
1	Preliminary	100	100	100	100
2	Core activities				
	– Stimulation	100	100	100	100
	– Problem statements	100	100	100	100
	– Data collection	100	100	100	100
	– Data processing	100	100	100	100
	– Verification	100	100	100	100
	– Generalization	100	100	100	100
3	Closing	100	100	100	100
4	Time management	100	100	100	100
5	Teacher questioning technique	100	100	100	100
6	Class situation	100	100	100	100
	Average	100	100	100	100

3.2.2. Results of students' written test

The cognitive aspects of students can be seen from the results of the tests that were carried out at the third meeting, which is the end of the second cycle. The test aimed to see students' understanding regarding the material exchange of oxygen and carbon dioxide in the human lungs, diseases of the respiratory system and the dangers of smoking for humans. The questions given were 20 multiple-choice questions. The test result data is shown in Figure 3.

Based on Figure 3, the lowest score obtained by students was 50, and the highest score was 100. The frequency of scores that were obtained the most was in the range of 80-89, with as many as 13 people, while the frequency of scores obtained in the range of 50-59 was only one person. Five students obtained scores below the MCC with a value range of 50-69, while 25 obtained scores in a range of 70-100. The percentage of completeness of Cycle II obtained from the test results can be seen in Figure 4. The test results in the second cycle in Figure 4 show that there were 25 students whose scores reached the MCC and were declared complete, namely 83.33%, while five students still needed to complete/had not reached the minimum completion criteria of 16.67%. The classical completeness result of 83.33% shows that the research actions carried out have achieved indicators of success.

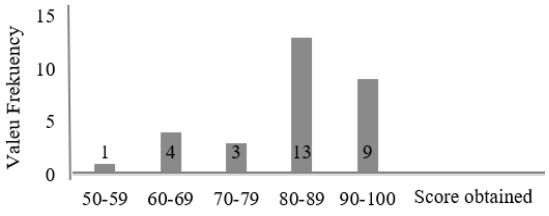

Figure 3. The test result data Cycle II

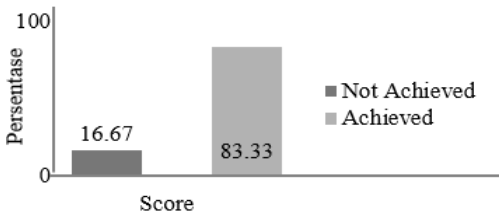

Figure 4. The percentage of completeness of Cycle II

3.3. Comparison of action results in Cycle I

The Table 3 compares the results of teacher activities in implementing the discovery learning model based on observations carried out by colleagues as in Cycle I to see the teacher's teaching activities. Observers observe the implementation of the learning process. The results of observer observations regarding the implementation of teacher activities in teaching in the classroom can be seen in the Table 3.

Table 3. The results of observations of the implementation teacher activities Cycle I and II

No	Teacher Activities	Cycle I (%)	Cycle II (%)	Description
1	Preliminary	100	100	Increase
2	Core activities:			
	– Stimulation	100	100	Increase
	– Problem statements	100	100	Increase
	– Data collection	100	100	Increase
	– Data processing	100	100	Increase
	– Verification	100	100	Increase
	– Generalization	83.33	100	Increase
3	Closing	77.78	100	Increase
4	Time management	66.67	100	Increase
5	Teacher questioning technique	66.67	100	Increase
6	Class situation	66.67	100	Increase
		Average	100	Increase

The results of observations of teacher activities in implementing the discovery learning model in the learning process increased from Cycle I by 87.37% to 100% in Cycle II with a very good category. A comparison of student knowledge test results obtained from Cycle I and II test results can be seen in the Table 4. The data in Table 4 shows an increase in the learning outcomes of the cognitive aspects of students in Cycle II. The frequency of the highest scores obtained by students was 50-59 for as many as nine people, and the frequency of students who obtained scores in the range of 40-49 was for only two people. In Cycle II, the frequency of scores obtained by students was 80-89, with as many as 13 people, while the frequency of scores in the range of 50-59 was only one person. The average value and the percentage of students' completeness in Cycle I and II can be seen in Table 5.

Table 4. The test results in Cycle I and II

No.	Scores	Cycle 1	Cycle 2
1	40-49	2	0
2	50-59	9	1
3	60-69	3	4
4	70-79	7	3
5	80-89	6	13
6	90-100	3	9

Table 5. The percentage of students' completeness in Cycle I and II

No	Descriptions	MCC	Cycle I	Cycle II
1	Average scores	70	68	81
2	Number of completed students		16	25
3	Number of uncompleted students		14	5
4	Completeness percentage		53.33	83.33

Data from Table 5 shows that the average value in Cycle I was 68, while in Cycle II, it increased to 81 a comparison of the percentage of completeness in Cycle I and II can be seen in Figure 5. Figure 5 shows an increase in the percentage of students who completed and a decrease in the percentage of students who did not. In the first cycle, students who obtained a complete score were 53.33%, while in the second cycle, there was an increase in students who completed 83.33%. Thus, the increase in completeness from Cycle I to II was 20%. Students who did not complete decreased from the first cycle 46.67% to the second cycle of 16.67%. Therefore the percentage of students who did not complete decreased by 30%.

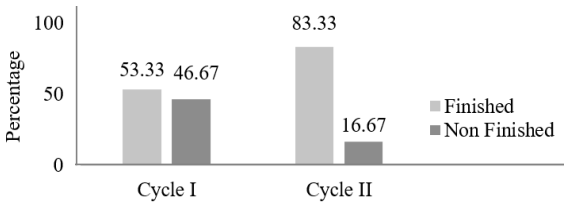

Figure 5. The percentage of completeness in Cycle I and II

Based on the results of the knowledge test in the second cycle, there was an increase in the percentage of classical completeness of 83.33%, meaning that the success of students on the written test had reached the indicator of the success of the research activities, which was more than 70%. According to Saripudin *et al.* [25], the indicator of achievement of the action is successful if 70% of the students can achieve a value of 70. This shows that applying the discovery learning model in learning can improve student learning outcomes. In Cycle II, the teacher provided more motivation and aroused students' enthusiasm for learning to find out and find information for themselves by providing a stimulus not just pictures or questions but through videos, as well as simple practicums. In addition, the teacher awakens the spirit of student cooperation in groups by forming new groups and providing guidance and motivation by awarding the best group title. Discussion and presentation activities can foster student confidence and deepen understanding of the studied material [26]. Fauziah and Nurita [27] told that structured guidance can facilitate students' understanding of natural sciences, making it easier for them to grasp challenging topics. The teacher also provides student worksheets as student work material. PowerPoint and videos from the internet are additional reference materials for collecting and processing data on student worksheets.

Knowledge aspect learning outcomes indicate students' success in receiving and understanding lesson material, so they are said to be successful if the desired learning objectives can be achieved. Increasing student learning outcomes is also supported by teachers' increasing teaching activities in implementing learning models and increasing classroom learning activities [26]. Thus, a learning process that is carried out well will influence the final learning outcomes. According to, using student worksheets in the learning process helps students learn and helps them discover material concepts [27]. This aligns with the findings of, who note that teachers' experiences and identities significantly influence their willingness to adopt innovative teaching strategies, such as discovery learning [28].

Similar research regarding the application of discovery learning models that have an impact on improving student learning outcomes was carried out by Rosnidar *et al.* [29]. The discovery learning model

can improve the learning outcomes of class XI students on the material of the coordination system the research results of [30], the application of the discovery learning model can improve science learning outcomes, and it is supported by the research results of [31], that the discovery learning model can improve the learning outcomes of class VII students on respiratory system material.

3. CONCLUSION

In Madrasah Aliyah Negeri 1 Palembang, problems were found with scores below the MCC. After conducting CAR for two cycles with three meetings, there was an increase in scores above the MCC. Actions taken by implementing the discovery learning model can improve learning outcomes. The increased learning outcomes were accompanied by increased student activity in asking, answering, and discussing. The percentage of learning outcomes in the first cycle of cognitive aspects from 53.33% of students who obtained a score above the MCC with an average score of 68 increased by 83.33% with an average score of 81 in Cycle II.

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