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Improving Students' Learning Outcomes and Activities through the Implementation of the Discovery Learning Model on Mol Concept Material

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Abstract

This study aims to describe the implementation of discovery learning, the responses of students which are supported by the activities carried out by students, as well as the learning outcomes of students through the implementation of discovery learning models on the mole concept material. This research is a Classroom Action Research (CAR) which was carried out for two cycles. The research subjects were 32 students in class X-3 at SMA Negeri 13 Surabaya for the 2022/2023 academic year. The data generated in this study are summarized as follows: (1) The implementation of the learning syntax of the discovery learning model in cycle 1 and cycle 2 obtained a percentage of implementation of 90.97% and 95.37% with excellent criteria. (2) The application of the discovery learning model received a positive response with a percentage of 81.25-100 so it was declared excellent and supported by a greater percentage of relevant student activities than irrelevant activities. Student activity observed in each phase of learning activities using the discovery learning model shows that the percentage of relevant activities from cycle 1 and cycle 2 gets percentages of 94.41% and 96.71%. While activities that are not relevant are 5.59% in cycle 1 and 3.29% in cycle 2. (3) In cycle 1, the learning outcomes of students who scored ≥ 75 were declared complete with a classical completeness of 78.12% and a class average score of 85.34. In cycle 2, the learning outcomes of students who scored ≥ 75 were declared complete with classical completeness of 100% and the class average score was 96.90. Based on the data obtained, it can be concluded that learning outcomes and student activity improved through the implementation of the discovery learning model.

Keywords: Discovery Learning, Learning Outcomes, Student Activities, Mol Concept

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INTRODUCTION

The educational process that functions as an instrument to achieve education goals is competence achievement. In line with that, the Ministry of Education, Culture, Research and Technology of the Republic of Indonesia states that each educational unit implements lesson plans, implements the learning process, and evaluates the learning process to increase the effectiveness and efficiency of graduate competencies (Mayudana & Sukendra, 2020). One of the efforts to realize an innovative learning process that follows the needs of students (student-centered) is to update the education curriculum in Indonesia. The current curriculum is the Independent Curriculum (Vhalery et al., 2022). The Independent Curriculum involves independent conditions in fulfilling the goals, methods, materials, and evaluation of learning for both teachers and students. With this, it can be seen that the learning process in the independent learning curriculum is more directed to the needs of students whereas previously the concept of learning was still centered on the teacher (Pertiwi et al., 2022).

The independent Curriculum is present as an answer to the intense competition for human resources globally in the Era of Society 5.0 which takes place in the 21st Century which is the

glory of the digital world (Indarta et al., 2022). The 21st century learning model also requires 4C skills which consist of creativity, critical thinking, collaboration, and communication (Hidayati et al., 2021). In line with this, learning with a scientific approach is needed. For the sake of realizing learning with a scientific approach, one way that can be done is to implement an effective learning model (Nurkholik & Yonata, 2020).

Based on the outcomes of observations of the implementation of learning conducted by researchers in class X-3 SMA Negeri 13 Surabaya, the researchers obtained results if the teacher still applied the lecture method in the class. The teacher applies the lecture method because it is considered more practical and can be done without using learning media. The lecture method can make students accept whatever the teacher gives without giving opinions or asking questions. This learning method results in students not having the opportunity to build their knowledge so students understanding of the learning material presented is still lacking. Based on the results of observations made by researchers when students worked on daily chemistry test questions, students could only work on questions with a low level of difficulty and simple types of questions that had been exemplified by the teacher. Whereas in questions that are more varied and with higher difficulty, students have difficulty finding ways to work on these questions.

The field study results showed that 50% of class X-3 students at SMA Negeri 13 Surabaya received daily chemistry test scores under the Minimum Completeness Criteria (MCC) with an average score of 71.75. The minimum completeness criterion for chemistry class X at SMA Negeri 13 Surabaya is 75. The daily test consists of 20 essay questions about electron configurations, quantum numbers, and the periodicity of elements. Contrary to students' understanding, as much as 81.25% of students like chemistry material because students like material that contains algorithmic understanding. Based on the learning outcomes data, it can be concluded that the lecture method causes low student learning outcomes. This is supported by research conducted by Adilah which shows that the lecture method cannot improve student learning outcomes because the learning process tends to be teacher-centered. Therefore, students are passive when asking questions and giving opinions on learning material. Students also cannot develop what is in their minds about the material so the average student learning result is 63.49 (Adilah, 2017)

Based on the above problems, researchers will conduct Classroom Action Research. Classroom Action Research (CAR) is carried out using learning models and media that are adapted to the material to be delivered, the characteristics of the students, the learning facilities available, and the learning objectives so that it is expected to improve student learning outcomes (Arham & Dwiningsih, 2016). One learning model that can be applied is discovery learning. Discovery learning is a learning model that trains and guides students to learn, acquire knowledge, and construct concepts so that they discover for themselves (Ferdiansah et al., 2020). Following the demands of the Independent Curriculum, students are expected to be more actively involved and not only depend on explanations from the teacher. Wilcox (in Wulandari, 2016) states that discovery learning motivates students to learn through their involvement with concepts and principles (Wulandari, 2016). The concept discovery process is carried out through students observing, classifying, hypothesizing, explaining, formulating conclusions, and so on (Kari et al., 2022). By selecting the discovery learning model, students are expected to be able to increase their learning activities in gaining knowledge so that it will have an impact on improving learning outcomes (Nugrahaeni et al., 2017).

The results of the Classroom Action Research (CAR) conducted by Jayadiningrat showed that the implementation of the discovery learning model could increase the activities and results of chemistry learning in class XI MIPA 2 students at SMAN 3 Singaraja. This can be seen from the increase in the percentage of student learning activities from 74% in cycle 1 to 84% in cycle 2. In addition, the implementation of the discovery learning model can also increase the average percentage of student learning outcomes from 74% of students in the good category in cycle 1 to 88% of students in the good category in cycle 2 (Jayadiningrat et al., 2019).

Discovery learning can be applied, among others, to chemistry subjects about the concept of moles (Siahaan et al., 2022). The concept of the mole is one of the subject matter of chemistry. The material discussed in the mol concept is a relative atomic mass (Ar), relative molecular mass (Mr), moles, mass, number of particles, and gas volume (Sari et al., 2020). This material is abstract because students must apply conceptual and algorithmic understanding. This statement is supported by the results of Nilawati's research which was obtained before learning activities with the chosen learning model, as much as 100% of students still had conceptual errors in calculating Relative Molecular Mass (Mr), and 70% of students still experienced conceptual errors in calculating the number of particles of a substance (Nilawati et al., 2017).

Research conducted by Siahaan related to the effect of the use of discovery learning-oriented student worksheets on student learning outcomes in the mole concept material. In seeing how much influence the use of discovery learning-oriented student worksheets has, Siahaan performs calculations using Effect Size. In calculating the Effect Size using Glass's Delta formula, the results show that there are significant differences in student learning outcomes in the mole concept material with high changes (Siahaan et al., 2022). Based on the description of the problems above, researchers will conduct Classroom Action Research (CAR) which can improve student learning outcomes and student activities in class X-3 at SMA Negeri 13 Surabaya through the implementation of discovery learning models on the mole concept material.

METHOD

The research was conducted at SMA Negeri 13 Surabaya. This type of research is Classroom Action Research (CAR), which has 2 cycles. Researchers apply the learning model of discovery learning in 2 cycles. The subjects in this study were 32 students in class X-3 at SMA Negeri 13 Surabaya. Teachers and students are a source of data in this study. Data collection techniques through tests and non-tests consisting of the implementation of discovery learning models, response questionnaires, student activity sheets, and tests to determine student learning outcomes. Data analysis in the implementation of CAR was carried out from the beginning until the last data was obtained. The results of the data obtained from the research were then analyzed and processed in a qualitative and quantitative descriptive manner. The implementation of the stages of the discovery learning model is obtained from the score given by the observer. Table 1 below is the criteria for assessing the ability of teachers:

Table 1. Teacher Ability Criteria Score

Score	Criteria
0	Not implemented
1	Implemented, out of comission, not interactional mutual, and not on schedule
2	Implemented, in sequence, not interactional mutual, and not on schedule
3	Implemented, in sequence, interactional mutual, and not on schedule
4	Implemented, in sequence, interactional mutual, and on schedule

The following is a syntax implementation formula by entering score data obtained from observers:

$$\text{Syntax execution (\%)} = \frac{score\ obtained}{score\ maximum} \times 100\%$$

Table 2. Criteria for the Implementation of the Discovery Learning Learning Model (Riduwan, 2015)

Percentage(%)	Criteria
0-20	Very less
21-40	Less
41-60	Enough
61-80	Good
81-100	Excellent

Based on Table 2. The implementation of the Discovery Learning learning model is stated to be good if the percentage is ≥ 61%. The response questionnaire instrument was used to determine the response to the learning material developed and the response to discovery learning-oriented learning provided by researchers. Student response questionnaires contain filling instructions, statements, and yes-no columns. Analysis of student response questionnaires by changing the frequency values into percentages using the formula:

$$P\ (\%) = \frac{F}{N} \times 100\%$$

Description:
P = response percentage
F = number of students who responded positively
N = number of respondents

Table 3. Assessment Criteria for Implementation of the Discovery Learning Learning Model from Student Questionnaire Results

Percentage (%)	Criteria
0-20	Very less
21-40	Less
41-60	Enough
61-80	Good
81-100	Excellent

(Riduwan, 2015)

Based on the criteria in Table 3, if the percentage of student responses is ≥ 61%, then the implementation of the discovery learning model can be said to be good and very good. The practicality of implementing discovery learning models is also supported by the activities of students when carrying out learning activities if the percentage of relevant activities is greater than irrelevant activities. Activities were carried out by students while receiving learning, then analyzed descriptively quantitatively based on the average results of 3 observers for 5 minutes once. The results of the data are calculated by the following formula (Arifin, 2009).

$$\text{Activity Percentage (\%)} = \frac{\sum \text{frequency of activity that appears}}{\sum \text{frequency of overall activity}} \times 100\%$$

Based on the results of these calculations, if the percentage of relevant activities is higher than the percentage of irrelevant activities when implementing the discovery learning model, then these student learning activities can support improving learning outcomes. Data analysis of learning outcomes in the realm of knowledge was obtained from the results of the test working on multiple choice questions as many as 8 questions per cycle. The value of learning outcomes is calculated using the formula:

$$\text{Score} = \frac{\sum \text{score obtained}}{\sum \text{score maximal}} \times 100\%$$

Indicators of success in applying the Discovery Learning model can be seen from students' learning outcomes if students achieve a Minimum Completeness Criteria (MCC) of ≥75. Class classical completeness can be calculated through the following formula:

$$\text{Classical completeness (\%)} = \frac{\sum \text{the number of students who achieved the MCC score}}{\sum \text{the number of students who took the test}} \times 100\%$$

The cycle will stop if the percentage of classical completeness obtained is ≥85%. If the percentage of classical completeness obtained is ≤85%, then the researcher will conduct classroom action research (Suprapti, 2021).

RESULTS AND DISCUSSIONS

Implementation of the Discovery Learning Model

Observation of implementation was assessed using the instrument of observation of implementation sheet. Observers of the learning process carried out were a chemistry teacher at SMA Negeri 13 Surabaya and 3 Unesa Chemistry Teacher Professional Education students.

The percentage of learning implementation for 2 cycles uses the Discovery learning model which is divided into 6 phases. The sub-subjects studied in cycle 1 are calculating the Relative Atomic Mass (Ar) and Relative Molecular Mass (Mr) of a substance; calculating moles, mass, and the number of particles of a substance; converting the number of moles with mass and number of particles; deduce the relationship between moles and mass and number of particles. The sub-topics studied in cycle 2 are calculating the volume of a substance; converting the number of moles to the volume of a substance; correctly converting the volume of a substance with moles, mass, and number of particles through discussion and question and answer activities; conclude the relationship between the concept of moles and the volume of a substance. The results of the implementation of cycle 1 and cycle 2 are shown in Figure 1.

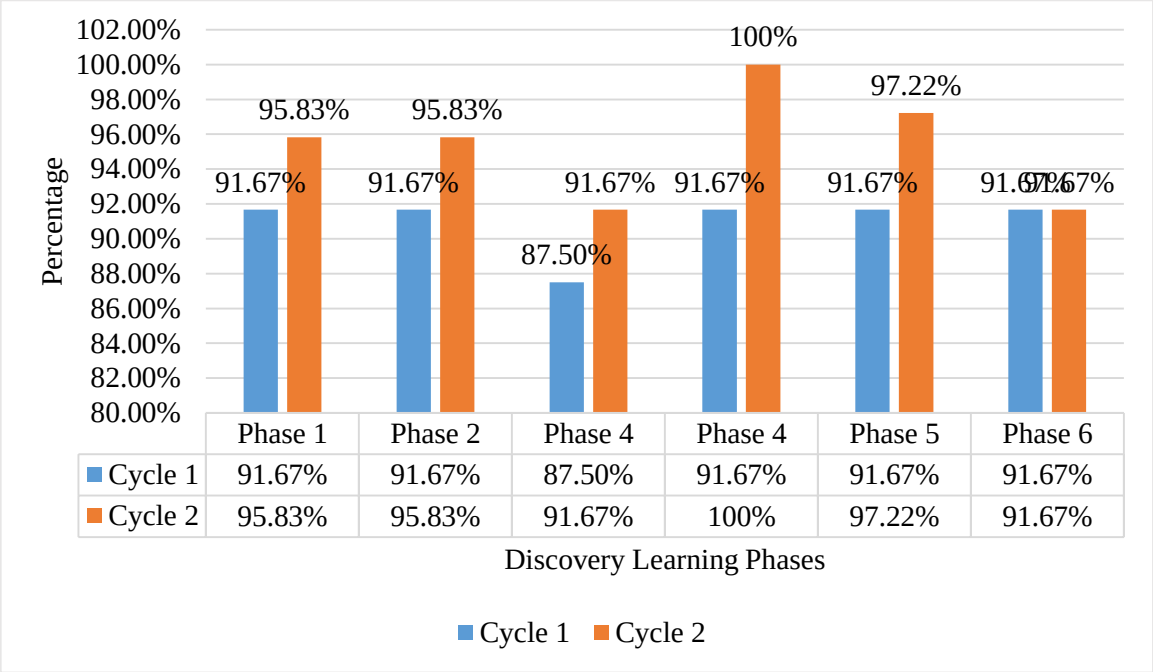

Figure 1. Implementation of the Discovery Learning Model

Based on Figure 1. Activities in phase 1 namely Stimulation (Imawan, 2015). The function of the stimulation phase is to prepare conditions for learning interaction that can develop and assist students in exploring learning material (Karoni, 2023). In phase 1, the teacher divides students into 7 heterogeneous groups then divides student worksheets, invites students to read phenomena, provides several questions related to phenomena in everyday life, and gives advice to students to read material literacy that leads to the preparation of problem-solving. Phase 1 activities in cycle 1 successively get scores from observers of 100%; 91.67%; 91.67%; and 83.33% so an average of 91.67% is obtained with excellent criteria. Phase 1 activities in cycle 2 successively get scores from observers of 100%; 100%; 91.67%; and 91.67% so that an average of 95.83% is obtained with excellent criteria.

Activities in phase 2 namely Problem Identification (Imawan, 2015). The function of the problem identification phase is to provide opportunities for students to identify and analyze problems in a given case so that they can build an understanding of the concept (Sartika et al., 2020). In phase 2, the teacher provides opportunities for students to identify problems that become learning materials and make hypotheses that are temporary at the beginning of learning activities. Phase 2 activities in cycle 1 successively obtained scores from observers of 91.67% and 91.67% so an average of 91.67% was obtained with excellent criteria. Phase 2 activities in cycle 2 successively obtained scores from observers of 100% and 91.67% so an average of 95.83% was obtained with excellent criteria.

Activities in phase 3 namely Data Collection (Imawan, 2015). The main function of the data collection phase is to provide opportunities for students to answer questions or prove whether the hypothesis from the previous phase is correct or not (Karoni, 2023). In phase 3,

the teacher provides opportunities for students to collect relevant information through literacy activities and present information about the mole concept through discussion activities. Phase 3 activities in cycle 1 successively obtained scores from observers of 91.67% and 83.33% so an average of 87.50% was obtained with excellent criteria. Phase 3 activities in cycle 2 successively obtained scores from observers of 91.67% and 91.67% so an average of 91.67% was obtained with excellent criteria.

Activities in phase 4 namely Data Processing (Imawan, 2015). The function of the data processing phase is to invite students to carry out activities to process data and information that has been obtained in the previous phase (Karoni, 2023). In phase 4, the teacher invites students to analyze and process data by working on questions on student worksheets. Phase 4 activities in cycle 1 get a score from observers of 91.67% with excellent criteria. Phase 4 activities in cycle 2 get a score of 100% from observers with excellent criteria.

Activities in phase 5 namely Verification (Imawan, 2015). In phase 5, the teacher guides students in presenting the data from the discussion results, gives instructions that other groups can ask questions about the results of the discussions submitted, provides feedback on the results of students' answers. In cycle 2, the teacher and students carry out quiz activities using the Numbered Heads Together (NHT) method to present the results of group discussions, give instructions that other groups can ask questions about the results of the discussions submitted, provide feedback on the results of student answers. The Numbered Heads Together (NHT) method is a form of cooperative learning that requires students to work together in small groups to complete their subject matter. Collaboration in groups is expected to encourage students to develop their thoughts, experiences, and active participation in learning so that learning interactions are established between students (Fitri et al., 2022). In practice, the teacher calls one of the student's headband numbers randomly. Students in a group with that number are asked to submit answers to the results of group discussions (Yenni & Mathematics, 2016). The teacher corrects the students' answers and writes down the scores obtained. Phase 5 activities in cycle 1 successively get scores from observers of 100%; 91.67%; and 83.33% so an average of 91.67% is obtained with excellent criteria. Phase 5 activities in cycle 2 successively get scores from observers of 100%; 100%; 91.67% so an average of 97.22% is obtained with excellent criteria.

Figure 2. Quiz Activity with the NHT Method

Activities in phase 6 namely Generalization (Imawan, 2015). In phase 6, the teacher asks students to draw a conclusion that can be used as a general principle. Phase 6 activities in cycle 1 and cycle 2 get scores from observers of 91.67% with excellent criteria. The most dominant phase is phase 4. In phase 4, students analyze and process data by working on questions on student worksheets so that students can test problem formulations, hypotheses, and conclude. Based on the description of the Discovery learning phases implemented at SMA Negeri 13 Surabaya, it can be said that each learning stage gets a percentage of ≥81% and gets excellent assessment criteria in the first cycle and the second cycle.

Student Activity

Learning activities are individual activities by carrying out interactions between individuals and individuals or individuals with the environment so that they can bring about changes for the benefit of these individuals (Wijaya, 2015). According to Sardiman (in Nuraini et al., 2018), students must gain knowledge by observing, experiencing, and investigating their work when carrying out learning activities. The learning activities of the students observed included activities in class and group activities. The number of observers was 3 people from Unesa Chemistry Teacher Professional Education students, one observer observed 2-3 groups with an observation frequency of 5 minutes by ticking on the observation sheet the most dominant activity appearing in that 5 minutes interval. The observation results obtained are shown in Figure 3.

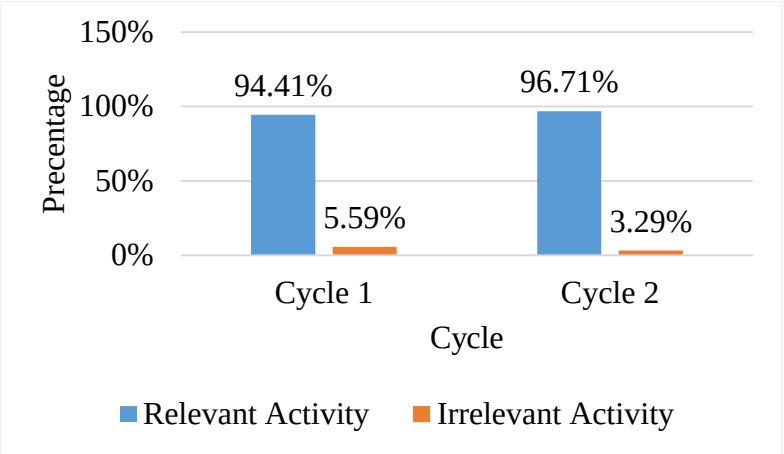

Figure 3. Student Activities

Figure 3 describes the learning activities of 32 students. Student activities consist of class activities (answering teacher questions, listening to teacher explanations, communicating the results of group discussions and expressing opinions) and group activities (reading and understanding phenomena in student worksheets, conducting group discussions to prepare problem solving on phenomena, identify problems that become learning materials, make problem formulations, make hypotheses that are temporary at the beginning of learning, collect information data to answer hypotheses, processing data, proving the results of group discussions through quiz activities with the NHT method, and drawing conclusions). The percentage of relevant activities is greater than irrelevant activities (playing cellphones, disrupting learning activities, busy doing activities other than learning activities, and doing other activities that can interfere with the course of learning activities). Relevant activities carried out by students increased from cycle 1 of 94.41% to 96.71% in cycle 2.

Figure 4. Data Processing Activities

The most dominant activity in each cycle is data processing activity with an average percentage value of 20.03%. This activity requires quite a long time to analyze and process data by working on questions on student worksheet so students can test problem formulations, hypotheses, and conclude.

Student Response

Assessment of the learning process by students was obtained from the results of response questionnaires distributed to students after learning activities were carried out. Interesting learning activities will make students happier and easier to get knowledge that can be seen from the responses of students during the learning process. Student response is a social reaction carried out by students in response to influences or stimuli from situations that are carried out by people (Kartini & Putra, 2020). As a teacher, the teacher must know the responses of students in learning activities so that educators can understand the way students think and are able to change the way students think that is good and right. The following table 4 contains the results of data processing related to student response questionnaires.

Table 4. Response Questionnaire Analysis Results

No.	Rated Aspect	Response Percentage (%)	Criteria
1.	Based on the learning you have done, are you interested in the following components?	Interested	Excellent
	The learning process, materials, student worksheets, learning atmosphere, and the way the teacher teaches	100	
2.	Do you find it easy to understand the components of learning activities contained in student worksheets?	Easy	Excellent
	Materials, phenomena, descriptions, questions, information, and terms	81.25	
3.	Do you agree with the following components:	Agree	Excellent
	Presentation of the learning process can motivate learning, encourage to be active, and arouse curiosity. Presentation of pictures in student worksheets helps to understand the material, formulas, and symbols are stated clearly.	90.62	
4.	Can you follow the following components?	Yes	Excellent
	Identifying problems, collecting data, processing data, proving, and making conclusions	93.75	
5.	What do you think about the way the teacher provides learning with the discovery learning model on the mole concept?	Good	Excellent
	Discovery learning stages from phase 1 to phase 6	93.75	
6.	Do you find it easy to answer evaluation questions?	Easy 81.25	Excellent
7.	Are you interested in participating in learning as you have done now to be applied to the next learning activity?	Interested 96.87	Excellent
The results of the student response questionnaire		81.25-100	Excellent

Based on Table 4 the application of the discovery learning model was stated to be very good because the percentage obtained was 81.25-100 indicating a positive response and supported by data from observations of student activity ≥ 61% of students were active during the implementation of learning activities.

Student Learning Outcomes

Learning outcomes are activities and achievements that involve and reflect the knowledge of students who successfully use content, information, ideas, and learning tools (Elde Mølstad & Karseth, 2016). The learning outcomes test is a test of the ability of students after receiving learning the mole concept by implementing the discovery learning model. The learning outcomes test shows the overall learning outcomes in the area of student knowledge by answering questions that are developed from indicators originating from the development of learning outcomes in the mole concept material.

In each cycle, students worked on 8 questions with a correct score of 12.5 per item. At the end of the learning process in cycle 1, students are given a test so that the teacher can find out and identify the level of success of students in the learning process that has been implemented. The following is a recapitulation of student learning outcomes in cycle 1.

Table 5. Recapitulation of Student Learning Outcomes in Cycle 1

No.	Description	Results from Cycle 1
1.	Average test score	85.34
2.	The number of students who complete learning	25 of 32
3.	Percentage of learning completeness	78.12%

From the table above it can be explained that the application of the discovery learning model in cycle 1 obtained an average value of student learning outcomes of 85.34. There were 26 out of 32 students who had finished studying so that the learning completeness reached 78.12%. These results indicate that students have not finished studying in a classical manner because students who obtain a Minimum Completeness Criteria (MCC) score of ≥75 are only 78.12%. These results are smaller than the specified classical completeness percentage. The percentage of classical completeness that must be achieved is ≥85%. This is because students are still unfamiliar with the implementation of learning using the discovery learning model.

Based on the results obtained in the first cycle where learning completeness has not reached the achievement target, it is necessary to take further action by conducting learning in cycle II. Learning in cycle II is carried out to improve the learning process in cycle I so that it is hoped that all students can achieve MCC scores. Learning activities in cycle II were carried out by the teacher by implementing the same learning model as cycle I, namely Discovery Learning, but the teacher also applied a new learning method, namely Numbered Heads Together (NHT) based quiz activities in phase 5 in the Discovery Learning model. With these learning models and methods, it is expected that student learning outcomes will increase. In addition, teachers also improve their ability to implement discovery learning learning models. The following is a recapitulation of student learning outcomes in cycle 2.

Table 6. Recapitulation of Student Formative Test Results in Cycle 2

No.	Decription	Results from Cycle 2
1.	Average test score	96.90
2.	The number of students who complete learning	32 of 32
3.	Percentage of learning completeness	100%

From the table above it can be explained that the application of the discovery learning model in cycle 2 obtained an average value of student learning outcomes of 96.90. All students in the class have finished studying so that the learning completeness reaches 100%. These results indicate that students complete learning classically because students who score ≥75 are 100%. These results have met the specified completeness percentage criteria, namely ≥85%. The following graph compares the percentage of completeness in cycle 1 and cycle 2.

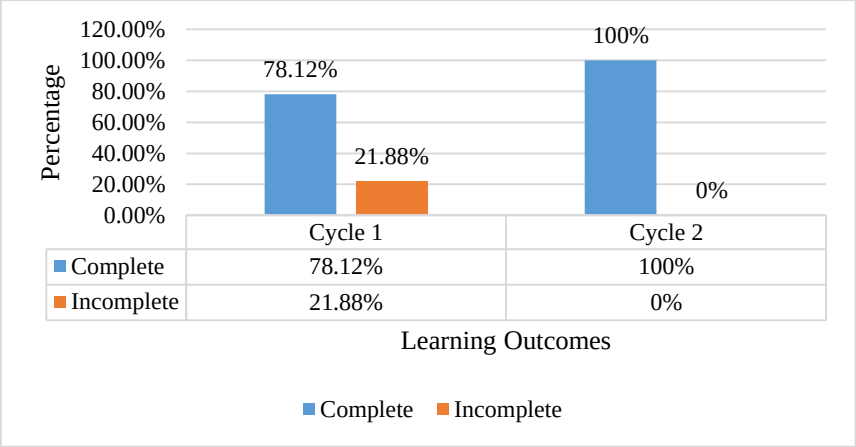

Figure 5. Completeness Percentage in Cycle 1 and Cycle 2

Figure 5 shows that there is an increase in the percentage of students who complete from cycle 1 to cycle 2. The increase in the completeness of student learning outcomes from cycle 1 is 78.12% to 100% in cycle 2. The completeness of the learning outcomes is supported by the quality of the implementation of the discovery learning learning model with excellent criteria and the relevant activities carried out by students during the learning process are greater than irrelevant activities. This is in line with the research conducted by Siahaan regarding the effect of the use of discovery learning-oriented student worksheets on student learning outcomes on the mole concept material. The results of the research statistical tests conducted by Siahaan showed that there were significant differences in student learning outcomes in the mole concept material with high changes. This shows that student learning outcomes and student activities can increase after the discovery learning model is applied to learning activities for 2 cycles (Siahaan et al., 2022).

CONCLUSION

Based on Classroom Action Research (CAR) data conducted in 2 cycles, it can be concluded that the learning outcomes and activities of class X-3 students of SMA Negeri 13 Surabaya improved through the implementation of the discovery learning model. This is supported by the percentage of the implementation of the discovery learning model, the percentage of student response questionnaire results, the percentage of student activity, and student learning outcomes. The implementation of learning activities using the discovery learning model in cycle 1 and cycle 2 obtained successive percentages of 90.97% and 95.37% with very good criteria. This is shown from the results of the percentage of the quality of implementation of each phase in cycle 1 and cycle 2 which is dominant with excellent implementation quality criteria, namely above 80%. The implementation of the discovery learning model received a positive response with a percentage of 81.25-100 so that it was declared excellent and supported by a greater percentage of relevant student activities than irrelevant activities. Student activity observed in each phase of learning activities using the discovery learning model shows that the percentage of relevant activities from cycle 1 and cycle 2 gets percentages of 94.41% and 96.71%. While activities that are not relevant are 5.59% in cycle 1 and 3.29% in cycle 2. In cycle 1, the learning outcomes of students who scored ≥ 75 were declared complete with a classical completeness of 78.12% and a class average score of 85.34. In cycle 2, the learning outcomes of students who scored ≥ 75 were declared complete with classical completeness of 100% and the class average score was 96.90.

RECOMMENDATION

Implementation of the discovery learning model on mole concept material can be done by utilizing the development of learning media such as student worksheets, learning videos,

and others. Researchers can also apply the discovery learning model to improve student learning outcomes and student activities in other chemistry materials.

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