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Implementation of the Learning Cycle 5E Learning Model Assisted by Scaffolding to Improve Students' Learning Outcomes and Science Process Skills on Buffer Solution Material.

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Abstract: Implementation of the Learning Cycle 5E Learning Model Assisted by Scaffolding to Improve Students' Learning Outcomes and Science Process Skills on Buffer Solution Material. This study aimed to determine the effectiveness of the Learning Cycle 5E model assisted by scaffolding in improving students' learning outcomes and science process skills on buffer solution material. The research design used was one group pretest-posttest involving students of class XI MIA at SMA Negeri 4 Medan. The intervention was conducted in three learning cycles. Data were collected using pretest-posttest instruments and science process skill observation sheets. The N-Gain results showed an increase in students' learning outcomes from cycle I (0.52), cycle II (0.69), to cycle III (0.73), with an average gain score of 64.63%, categorized as moderately effective. Science process skills of students reached a high level with an average score of 73.61%. implementation of the Learning Cycle 5E model assisted by scaffolding is effective in enhancing students' understanding and scientific skills in buffer solution learning.

Keywords: Learning Cycle 5E, Scaffolding, Learning Outcomes, Science Process Skills, Buffer Solution.

Abstrak: Implementasi Model Pembelajaran Learning Cycle 5E Berbantuan Scaffolding Terhadap Peningkatan Hasil Belajar Dan Keterampilan Proses Sains Siswa Pada Materi Larutan Penyangga. *Penelitian ini bertujuan untuk mengetahui efektivitas model pembelajaran Learning Cycle 5E berbantuan scaffolding dalam meningkatkan hasil belajar dan keterampilan proses sains siswa pada materi larutan penyangga. Penelitian ini menggunakan desain one group pretest-posttest dengan subjek siswa kelas XI MIA SMA Negeri 4 Medan. Pembelajaran dilakukan selama tiga siklus. Data dikumpulkan melalui instrumen pretest-posttest dan lembar observasi keterampilan proses sains. Hasil analisis N-Gain menunjukkan peningkatan hasil belajar dari siklus I (0,52), siklus II (0,69), hingga siklus III (0,73), dengan rata-rata 64,63% (kategori cukup efektif). Keterampilan proses sains siswa tergolong tinggi dengan skor rata-rata sebesar 73,61%. Penerapan model pembelajaran Learning Cycle 5E berbantuan scaffolding terbukti efektif dalam meningkatkan pemahaman konsep dan keterampilan ilmiah siswa pada materi larutan penyangga.*

Kata kunci: *Learning Cycle 5E, Scaffolding, Hasil Belajar, Keterampilan Proses Sains, Larutan Penyangga.*

▪ INTRODUCTION

Buffer solution is one of the branches of chemistry that contains abstract concepts involving theoretical principles that cannot be observed with the naked eye (Widyaningrum et al., 2023). Chemistry learning, especially in buffer solution material, is often a challenge for students because the material examines abstract concepts and contains complex concepts. In addition, based on research by Kurniawati et al, (2023) students experience difficulties in buffer solution material due to a lack of understanding of concepts in prerequisite material and weak student calculation skills. This is in line with Genes et al, (2021) learning difficulties in buffer solution material because students do not have basic concepts from previous material so that students are unable to solve problems and have difficulty understanding more complex concepts.

Based on the average student scores in the 2023/2024 school year, less than 50% of students reached the KKM. The difficulties that students often experience when learning buffer solutions are difficult to distinguish between acidic buffer solutions and basic buffer solutions. During learning, the teacher provides structured assistance (Scaffolding) which is usually done individually by inviting students to the front to ask the teacher directly about parts that are difficult to understand, it can also be given Scaffolding in groups. Scaffolding in groups is done by teachers directing students to discuss with friends who have understood the material as assistance in the form of peer tutors. According to Nurfajriani & Sundari (2021) with peer tutors, students can be more active in discussions and can improve student learning outcomes.

Based on the observation, it is known that students' skills are still relatively low. Students often have difficulties when classifying the results of observations, are less able to link the theory with the data obtained and conclude the results of their research. Most students when making conclusions based on theory are not based on the results of their experiments.

Science process skills are a scientific ability that students must have which requires students to be able to observe, classify, communicate, measure, predict and conclude (Fitriani et al., 2021).

According to Siahaan et al, (2020) science process skills in students must continue to be trained so that students are capable of scientific activities. According to Putra et al., (2015) Science Process Skills aims to train and improve students' intellectual or thinking abilities, as well as hone their cognitive, motor and social skills. In addition, KPS is also intended to encourage student creativity, so that they can actively develop and apply their abilities in learning.

According to Purnasari & Sadewo, (2020) one of the appropriate learning models for process skills and understanding of student concepts in this study is the Learning Cycle 5E learning model. This learning model can help students learn new concepts or try to understand familiar concepts in depth. According to Mustofa (2019) learning on the 5E learning cycle is cyclical learning with five stages that are student-centered. The five phases in this learning include Engagement, Exploration, Explanation, Elaboration, and Evaluation.

Learning Cycle 5E is a learning model based on constructivism that places students as the center of learning activities. In this model, students are encouraged to be actively and interactively involved, and are trained to discover and build their own knowledge. Each stage in this model is designed to develop critical thinking, process skills, and in-depth understanding of concepts (Pratiwi, 2016).

The Learning Cycle 5E model involves skills and activities that increase students' curiosity in learning materials, help students and make students become more focused and active in obtaining information and understanding. So that students are able to use their previous knowledge in finding new concepts to get more meaningful concepts. Learning Cycle 5E is a student-centered cyclical learning that can improve students' basic science process skills (Salosso et al., 2018). Using the Learning Cycle 5E model can make students actively involved in discussion activities and apply each stage in the 5E cycle (Sari et al., 2023).

Kurniawati (2021) emphasizes the importance of implementing science process skills in science learning at school, which shows that the application of science process skills must be supported by the right learning model. In the research of Salosso et al, (2018) applied the Learning Cycle 5E learning model on the subject of acid and base solutions, and showed an increase in students' science process skills. Scaffolding can be given full assistance at first but along with the development of students' abilities and the next stage the teacher reduces assistance so that students are able to do it themselves (Nordlof, 2014). In addition, scaffolding has advantages over conventional learning approaches, namely that it can foster a sense of student responsibility in completing the assigned tasks, increase student creativity, improve students' ability to think systematically, increase student activeness in learning, and can increase student learning motivation (Kusumaningsih & Azman, 2018).

In the context of scaffolds, Fajriani et al, (2021) showed that providing scaffolding in problem-based teaching materials can improve learning outcomes and students' higher-order thinking skills. Suroyalmilah et al, (2018) stated that the application of scaffolding can improve students' metacognitive abilities and concept understanding.

According to Setyaningrum & Sartika (2020), the addition of Scaffolding to the Learning Cycle 5E is effective in improving students' concept understanding.

▪ METHOD

This research was conducted at SMA Negeri 4 Medan which is located at Jl. Gelas No.12, Sei Putih Tengah, Kec. Medan Petisah, Medan City, North Sumatra 20118. This research lasted for approximately eight months starting from the preparation of the research proposal to the preparation of the final report.

The population in this study were all students of class XI MIA SMA Negeri 4 Medan. The sample in this study were students of class XI-5. In determining the sample in this study using purposive sampling technique**.** The use of purposive sampling techniques is necessary to prevent bias in sample selection and ensure that the data obtained is appropriate and supports the research objectives (Nyimbili & Nyimbili, 2024).

This research was conducted for 3 meetings, which means that during the research, 3 learning cycles were carried out. To see whether or not there is an increase in student learning outcomes by using the learning cycle 5E learning model assisted by scaffolding, a pretest-posttest is given in each learning cycle. Meanwhile, to measure the level of students' science process skills by observing student activities carried out during practicum activities in the third cycle. In its application, scaffolding is given as additional guidance that helps students overcome difficulties in understanding buffer solution material. This scaffolding includes question guides, experimental instructions, group discussions to ensure students are able to complete learning tasks properly.

In this study using one class as an experimental class. In the experimental class and taught with the learning cycle 5E learning model assisted by scaffolding.

Table 1. Research Design

Class	Pretest	Treatment	Posttest
Experiment	Q_1	X	Q_2

Description:
X = Learning with the Learning Cycle 5E model
Q_1 = Taking pretest data from the experimental class
Q_2 = Taking posttest data from the experimental class

This research design is used to find whether or not there is an increase in student learning outcomes after being given treatment through pretest and posttest results given in one learning cycle.

N-Gain Test

This test is conducted to determine whether or not there is an increase in results based on pretest and posttest scores of student learning outcomes related to student conceptual understanding. The N-Gain test was carried out by calculating the difference between the posttest and pretest scores.

$$\text{N-Gain} = \frac{posttest\ score - pretest\ score}{ideal\ score - pretest\ score}$$

According to Sukarelawan et al, (2024) the ideal score used is the maximum score or the highest score obtained, namely 100. The magnitude of the increase in N-Gain scores can be seen based on the normalized gain criteria which can be seen in table 2.

Table 2. Normalized Gain Criteria

N-Gain Score	Interpretation
$0{,}70 \leq g \leq 1{,}00$	High
$0{,}30 \leq g < 0{,}70$	Medium
$0{,}00 < g < 0{,}30$	Low
$g = 0{,}00$	No increase
$-1{,}00 \leq g < 0{,}00$	Decrease

To determine the effectiveness of the application of the intervention can be seen in table 3.

Table 3. Criteria for Determining the Level of Effectiveness

Percentage (%)	Interpretation
< 40	Not Effective
40-55	Less Effective
56-75	Moderately Effective
>76	Effective

Percentage of Science Process Skills

This test is conducted to determine the level of ability of students' science process skills. Analysis of the level of students' science process skills can be calculated by the formula:

$$NP = R/SM \times 100\%$$

Description:
NP : percentage value per indicator of science process skills
R : score obtained on the science process skills indicator
SM : maximum score on the science process skills indicator

According to Elvanisi et al, (2018) the classification of the level of students' science process skills which can be seen in table 3.8 is divided into 5 categories, namely very high, high, medium, low and very low.

▪ RESULT AND DISCUSSION

Student Learning Outcomes (N-Gain Score)

This research was carried out as many as 3 learning cycles which in each cycle included the stages of engagement, exploration, explanation, elaboration and evaluation.

Table 4. N-Gain Score

Cycles	N-Gain	Average N-Gain (%)	Description
1	0,52	64,63	Moderately Effective
2	0,69		
3	0,73		

Based on the data table above, the N-Gain value is obtained which shows that there is an increase in learning outcomes in each cycle. With an average N-Gain value of the three learning cycles obtained of 64.63% which means that the use of the Learning Cycle 5E model is “Moderately Effective” applied to learning material buffer solution.

Percentage Analysis of Students' Science Process Skills

Table 4. Student Science Process Skills Values

KPS Component	KPS Score	Average Percentage Score
Observing	75,69	73.61
Classifying	68,06	
Formulating a hypothesis	70,14	
Carrying out an experiment	71,53	
Interpreting data	83,33	
Concluding	76,39	
Communicating	70,14	
Average percentage score	73,61	

Based on the data table above, it can be seen that the level of students' science process skills is classified as “high” with an average value of 73.61

• DISCUSSION

Student Learning Outcomes (N-Gain Score)

In cycle 1, in the **engagement** ***phase,*** students were able to answer the ignition question well, this proves that students already understand acid-base material as a prerequisite material for buffer solutions. Then a *pretest* is given to find out the student's initial ability. In the **exploration** ***phase***, students observed the pH data of the buffer solution with the change in pH when a small amount of acid and alkaline solution was added to the table displayed. Next, students formed a discussion group to discuss the table data. In this phase*, scaffolding* is provided by guiding students in compiling an initial definition of the buffer solution, explaining the initial step in working on the discussion task with the aim that students can mention the right buffer solution based on the pH changes that occur in each solution. In the **explanation** ***phase***, the definition and types of buffer solutions are explained and accompanied by examples of solutions that form buffer solutions. In this phase, students are able to give their opinions on the components of the buffer solution appropriately. In the **elaboration** ***phase***, students are able to determine the buffer solution based on the table data by calculating the difference in pH change which then students are given the opportunity to convey the results of the discussion in front of the class. In the **evaluation** ***phase***, the learning results are summarized together and then a posttest is carried out to assess students' understanding of the material that has been taught. Then an N-Gain analysis was carried out in this cycle by looking at *the posttest-pretest score* obtained with an average N-Gain of 0.52 which was included in the increase in learning outcomes in the "moderate" category.

In cycle 2, in the **engagement** ***phase***, it is enough to be able to answer when asked a rebuttal question about the change in pH of a buffer solution if an acid, alkaline, and water solution is added. Then a pretest is carried out to measure students' initial understanding. In the **exploration** ***phase***, students observed explanations related to the calculation of pH in the buffer solution. In the **explanation** ***phase***, students work together in working on the assigned assignments in groups, given *scaffolding* to guide students in evaluating the answers to the assigned assignments. In the **elaboration** ***phase***, students are able to apply the calculation method that has been taught, then students communicate the results of the group discussion. In the **evaluation** ***phase***, students are given *a posttest* to measure students' understanding of the material that has been taught. Furthermore, in this cycle, an N-Gain analysis was carried out by looking at *the posttest-pretest score* obtained with an average N-Gain of 0.69 which is included in the improvement of learning outcomes in the "moderate" category.

In cycle 3, the **engagement** ***phase***, students were given a denying question related to the working principle of the buffer solution in maintaining the pH of the solution. Students were given *a pretest* to measure the student's initial ability. In the **Exploration** ***phase***, a brief explanation was given regarding the working principle of buffer solutions and examples of buffer solutions in daily life. In this phase, students conduct exploration by observing the phenomenon of buffer solutions by observing the process of color and pH change in each experiment and students record the data obtained in the LKPD. With *scaffolding guidance*, students not only carry out practicum activities, but are also directed to focus on observation and record data on the results of experiments on the LKPD that has been given. In the **explanation** ***phase***, students are able to explain their opinions about and be given *scaffolding* by helping students connect the results of the experiment with the appropriate theoretical concepts. In the **elaboration** ***phase***, students are able to apply the concepts learned in answering questions in the LKPD. In the **evaluation** ***phase***, each group was able to communicate the data of the experiment results in front of the class. Then a *posttest* is given to measure the student's initial understanding of the material that has been taught. To see the improvement in student learning outcomes, an N-Gain analysis was carried out in this cycle by looking at *the posttest-pretest scores* obtained with an average N-Gain of 0.72 which is included in the increase in learning outcomes in the "high" category.

The research was conducted in 3 meetings (3 cycles) which means that the N-Gain score in each cycle can be seen in the following table.

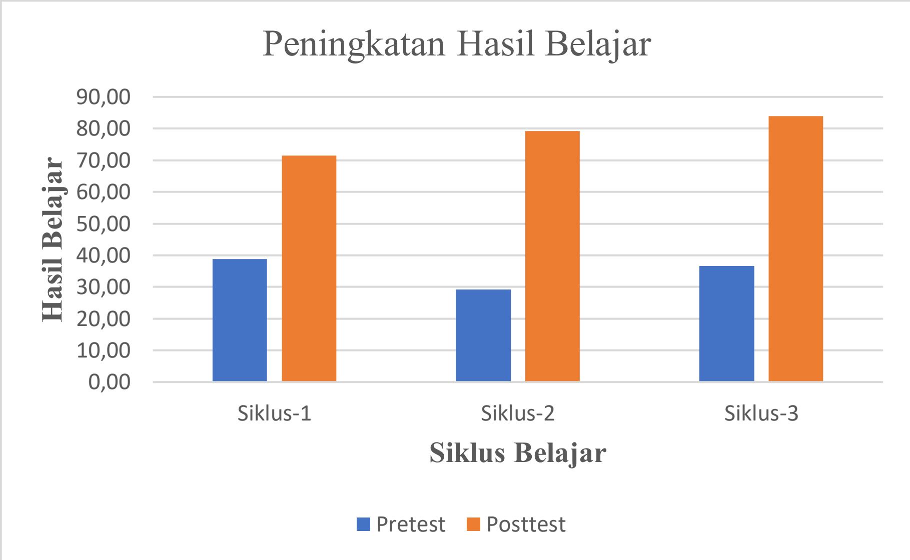

Figure 1. N-Gain Score

Based on the data above, the N-Gain score is obtained which shows that there is an increase in learning outcomes in each cycle. With an average N-Gain score of the three learning cycles obtained of 64.63% which means that the use of the Learning Cycle 5E buffer model is “Moderately Effective” applied to learning solution material.The results of the study are presented in the form of graphs, tables, or descriptive.

Based on the N-gain value obtained, it can be seen that there was an increase in learning outcomes from cycle 1 of 0.52, cycle-2 of 0.69, and cycle 3 of 0.72. This shows that by using the Learning Cycle 5E model in learning buffer solutions, there is an improvement in learning activities, understanding of concepts and scientific skills in students. This agrees with Salong & Lasaiba (2024) that the increase in learning outcomes shows that there is an increase in students' conceptual understanding and practical skills after being taught with the Learning Cycle 5E model. In addition, according to Dwi Septiani & Okmarisa (2023), the scaffolding approach in the learning process can relieve students in understanding certain material that is considered too difficult to understand so that students' concept understanding will be better.

Students' Science Process Skills

Science process skills can be measured by making direct observations when students do practicum. In this study, the science process skills measured include observations made to determine the level of skills in each student.

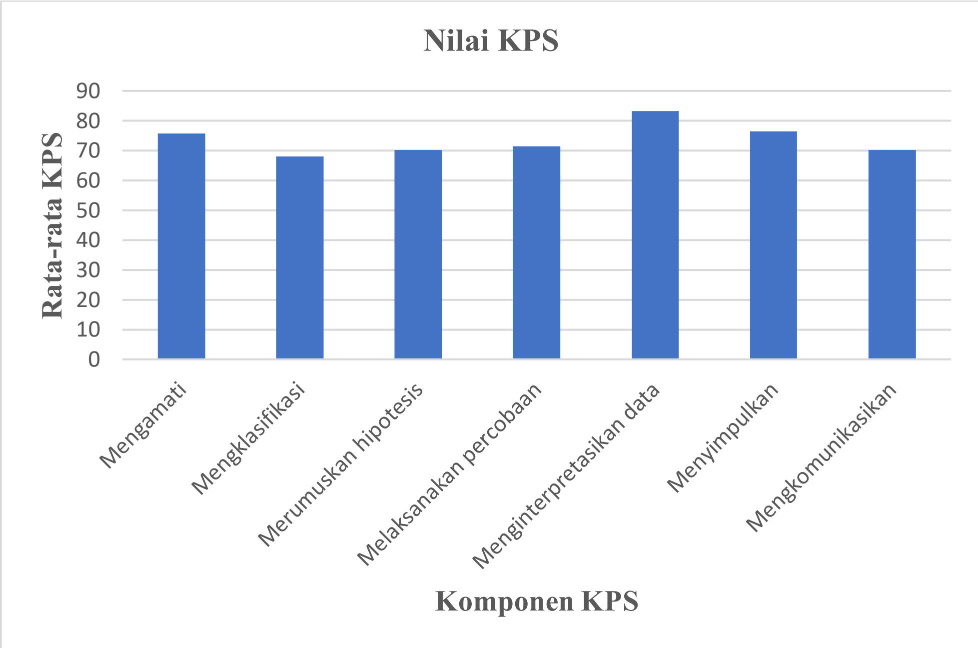

Figure 2. Graph of Students' Science Process Skills Levels

The level of students' science process skills has the highest value in the "Interpreting Data" component with an average value of 83.33. This indicates that students are quite capable of analyzing experimental results and drawing meaning from the data obtained. According to Jumiati & Martini (2021), this is because in the exploration phase students are involved in interpreting data and analyzing the data obtained so that students are accustomed to and capable of interpreting data. However, the level of students' science process skills in the "Classifying" component became the component with the smallest value of 75.69 which is included in the high category, meaning that students are quite capable of classifying buffer solutions and not buffer solutions. Overall, the level of students' science process skills is classified as "high" with an average percentage of 73.61, indicating that the model is successful in fostering students' scientific skills.

▪ CONCLUSION

Based on the results of research on the implementation of the Learning Cycle 5E learning model assisted by Scaffolding, it can be concluded that the model is proven to be able to improve student learning outcomes based on the average N-Gain value of 64.63 which is in the "Moderately Effective" category and the level of students' science process skills is classified as "high" at 73.61. The KPS component in the "classifying" component is the component with the lowest value and "interpreting data" is the component with the highest value.

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