The effectiveness of guided inquiry student worksheet to improve high order thinking skill in buffer solution material

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Abstract. This study revealed the effectiveness of guided inquiry student worksheets in improving high order thinking skills in buffer solution materials. This study was conducted with a non-equivalent control group design that uses 72 students as samples which are divided into experimental groups and control groups. The instrument used in this study is a high order thinking skills test given to each student before learning as a pre-test and after learning as a post test. Based on the results of the study, the N-gain value in the experimental class is higher than the control class, each of which has a value of 0.85 and 0.74. From the results of the t test using the SPSS statistical application, the significance value is 0.000 at the 95% confidence level and significance level (α = 0.05). Significance value <α so that it was concluded that the use of guided guided worksheet was effective in improving high order thinking skills of students.

1. Introduction

Entering the 21st century, the national education system faces a very complex challenge in preparing the quality of human resources that master various skills to be able to compete in the global era. The skills needed in facing the challenges of the 21st century, namely the skills of High Order Thinking Skills (HOTS) [1]. Thinking in high order thinking means being able to connect new information with previous knowledge and be able to apply the knowledge and skills developed during learning in the new context [2] [3]. By training high order thinking skills of students in the learning process, these students will easily solve new problems even though they relate to old knowledge that has been learned. In chemistry learning, one of the lessons that have a lot to do with the concepts that have been learned is the buffer solution material [4].

Based on observations at SMAN 3 Padang, SMAN 8 Padang and SMAN 13 Padang, it is known that the test questions used are still at the level of C1-C3 (low order thinking) cognitive processes. If the teacher gives a question at the level C4 - C6 (high order thinking) students tend to not be able to do it. These problems need to be addressed, one of them is by changing learning orientation, namely from low order thinking learning to learning that trains high order thinking skills. High order thinking skills can be achieved in line with the implementation of the 2013[1] curriculum. One way to support harmony between the 2013 curriculum and its implementation in the learning process is to use teaching materials.

The expected teaching materials are teaching materials arranged based on stages or learning models that can train high order thinking skills. One learning model that emphasizes students thinking skills is guided inquiry [5]. The inquiry in learning process consists of five stages namely orientation, exploration, concept formation, application, and closing [6]. Through the five stages of the guided inquiry learning process, students will train high order thinking skills and direct them to acquire knowledge by finding themselves.
In a previous study of learning with guided inquiry student worksheets provided positive data in improving student learning outcomes [7]. Therefore the researcher conducted a study on guided inquiry student worksheet effectiveness in increasing high order thinking skills of students.

2. Research Methods

2.1 Research Subject
This study used 72 students enrolled in two classes of SMAN 3 Kota Padang which were divided into 36 students in the experimental class and 36 in the control class.

2.2 Research Design
The type of research used is quasi experiment research. the quasi-experimental design used in this study was a non-equivalent control group design. In this design, the behavior of the experimental group and the control group is usually measured before and after treatment. The procedure for implementing a non-equivalent pretest-posttest control group design research design is that both groups were given an initial test or pre-test to measure the initial condition (01). This is done before being treated. Then the next step is to implement treatment (X) in the experimental group. For comparison groups were not treated. When the treatment is complete, the two groups are given another test or post-test (02). The scheme is as follows:

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01  X  02
03  04
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**Figure 1.** Non Equivalent Control Group Design [8]

Information:
01 = Pre-test experimental group
02 = experimental group post-test
03 = Pre-test control group
04 = control group post-test
X = Learning using guided inquiry-based Student Worksheets.

Based on the scheme above, it can be described that the effectiveness of treatment can be seen from the difference between (01-02) in the experimental group with (03-04) in the control group.

The hypothesis of this study is

Ho: The high order thinking skills of students in the buffer solution material did not improve significantly after using student worksheet based guided inquiry.

H1: The high order thinking skills of students in buffer solution material improve significantly after using student worksheet guided inquiry.

2.3 Data Collection
To test the effectiveness of guided inquiry student worksheets in improving high order thinking skills, a high order thinking skills test is given in the form of multiple choice questions. The answers from the students were analyzed and normalized Gain values were calculated using the N-Gain formula as follows [9].

\[
<\text{g}> = \frac{\%<\text{post test}> - \%<\text{pre test}>}{100 - \%<\text{pre test}>}
\]

Information :
\( \% <\text{post test}> = \text{average grade post test class} \)
\% \text{ pre test} = \text{average grade pre test}\% \\

The magnitude of the gain average \( g \) is interpreted based on the criteria in Table 1.

| Limited   | Criteria |
|-----------|----------|
| \( g \geq 0.7 \)  | High    |
| \( 0.3 \leq g < 0.7 \) | Mid     |
| \( g < 0.3 \)       | Low     |

3. Results and Discussion

3.1. Data description

Tests that have been answered by students are then examined. If students answer correctly, they will be given a score of 1 with a value of 8.33. If students answer incorrectly, they are given a score of 0 and a value of 0. An assessment like this applies to the pretest and posttest. The value of students in the sample class can be seen in the following table.

| Class      | N | Pretest | Postest |
|------------|---|---------|---------|
| Experiment | 36| 11.57   | 86.34   |
| Control    | 36| 11.34   | 76.85   |

Based on the table it can be seen that the value of the pretest of students is almost the same. Thus, the ability of the experimental class and sample class are the same. The posttest value shows the value of the experimental class is higher than the control class.

3.2. Data analysis

3.2.1 N-Gain. A summary of the N-gain value of each indicator can be seen in the following figure

![Figure 2. N-Gain values for each of the high order thinking skills indicators](image)

Based on the figure 2, it can be seen that the experimental class N-Gain value for each high order thinking skills indicator is higher than the experimental class. The overall value of N-Gain high order thinking skills for each sample class can be seen in Table 3.
Table 3. Student N-Gain Order Thinking Skills Value

| Class     | N-Gain | Criteria |
|-----------|--------|----------|
| Experimen | 0,85   | High     |
| Control   | 0,74   | High     |

Based on Table 3 above, it is known that the average N-Gain value for the experimental class is higher than the control class. Thus, guided inquiry-based student worksheets are effective for increasing students' high order thinking skills.

3.2.2 Normalities test. The SPSS statistical application is used for the normality test. Tests carried out using Kolmogorov-Smirnov. The results of the normality test can be seen in the following table.

Table 4. Normality Test Results

| Class     | $\alpha$ | Sig  | Distribution |
|-----------|----------|------|--------------|
| Experiment| 0,05     | 0,100| Normal       |
| Control   | 0,066    | 0,066| Normal       |

The significance value generated in the normality test is greater than the significance level ($\alpha$). Thus, data in both sample classes are normally distributed.

3.2.3 Test for homogeneity. Levine test was used to measure variance homogeneity with the help of SPSS statistical application. The homogeneity test results can be seen in the following table.

Table 5. Homogeneity Test Results

| Class     | $\alpha$ | Sig   | Variance |
|-----------|----------|-------|----------|
| Experiment| 0,05     | 0,978 | Homogen  |
| Control   |          |       |          |

Based on the results of the homogeneity test the resulting significance value is greater than the significance level ($\alpha$). Thus, data in both sample classes have a homogeneous variance.

3.2.4 Hypothesis test. Based on the results of the analysis described above, it is known that the value is normally distributed and has a homogeneous variance. Therefore in this hypothesis test using independent sample $t$-test with the help of SPSS statistical applications. Assessment criteria if the sigb value is greater than 0.05 then Ho is accepted while if the sig value is small than 0.05 then Ho is rejected hypothesis test results can be seen in the following Table.

Table 6. Hypothesis Test Results

| Class     | $\alpha$ | Sig | Decision |
|-----------|----------|-----|----------|
| Experiment| 0,05     | 0,000| Ho rejected|
| Control   |          |     |          |

Considering the table above, it can be seen that the significance value produced is smaller than the significance level so that Ho is rejected and H1 is accepted. This means that high order thinking skills of students who learn with student worksheet based guided inquiry increase significantly with students learning without using student worksheet guided inquiry.

4. Discussion

Guided inquiry-based LKPD effectiveness on buffer solution material towards high order students' thinking skills is measured by using high order thinking skills test instruments. This question amounts to 12 items. The problem for measuring high order thinking skills is designed with a cognitive level of
analysis (C4), evaluating (C5), and creating (C6). Questions with C4 cognitive level consist of 7 questions, while questions with cognitive level C5 are 3 questions and C6 2 questions. This question is given to students before learning as a pretest and after learning as a posttest.

Based on the calculation of the pretest value of the experimental class and the control class, the values obtained were 11.57 and 11.34 respectively. This value indicates that the initial abilities of the two classes are not much different. For the posttest value or value after learning the experimental class scored 86.34 and the control class 76, 85. This value indicates an increase in the value of the experimental class from pretest to posttest higher than the control class. This proves that the statement of high order thinking skills of students before and after using guided inquiry-based student worksheets is seen to increase during the initial test and final test. This result is the same as the previous study, where the value of students who were divided by inquiry-based student worksheets was higher than those who did not study with guided inquiry-based student worksheets [10] [11].

Based on the values obtained by students, an analysis of the ability of students in each indicator of high order thinking skills is conducted. The high order thinking skills indicator consists of C4 (analyzing), C5 (evaluating), and C6 (creating). Based on Figure 25 it can be concluded that each high order indicator of experimental class skills thinking has a higher N-gain score than the control class.

N-Gain and hypothetical test The N-gain test was conducted to see whether guided inquiry-based student worksheets were effectively used to improve high order thinking skills of students. The results of the N-Gain analysis show that the experimental class scored 0.85 while the control class scored 0.74. The N-gain value has high criteria [9]. This value shows the same results as the previous research, namely the N-gain value which learns with a high guided inquiry-based student worksheet [12].

This result is in line with the hypothesis test. Before testing hypotheses, the data obtained is first tested for normality and homogeneity. Based on the results of the analysis of normality and homogeneity using the SPSS statistical application it is known that the data is normally distributed and has a homogeneous variance. Therefore, in this hypothesis test using independent sample t-test with the help of SPSS statistical application [13]. Based on the results of the analysis that has been carried out obtained a significance value of 0,00. This value is smaller than the value of α (<0.05). So Ho is rejected. Ho's decision was rejected, meaning high order thinking skills of students who learned with guided inquiry-based student worksheets increased significantly than students who learned without using guided inquiry-based student worksheets. Guided inquiry learning develops students' thinking skills because using the learning cycle that guides students can build their understanding independently [5].

The orientation phase is the stage of preparing students to learn. At this stage students are motivated to learn buffer solutions so that they have curiosity about the buffer solution material. In addition to giving motivation at this stage students are also guided to remember the previous knowledge related to the buffer solution. Buffer solution material is closely related to several other materials such as the Bronsted Lowry acid base concept, chemical equilibrium, pH calculation and degree of ionization [4]. Therefore this orientation stage is very important because it will affect how students motivate to learn in the future.

In the experimental class the orientation stage is carried out by being explained directly by the teacher and supported by a guided inquiry-based student worksheet that presents the prerequisite and motivational material so that it can help foster learners' curiosity. Unlike the case with the control class, the orientation stage is done through the delivery by the teacher without being supported by the presentation on the student worksheet used.

The exploration phase is the stage where students have the opportunity to understand the material presented. At this stage it is assisted by a model and key questions. The use of the model here is very important. The model is a very important factor in learning chemistry that involves abstract and complex concepts [14]. Therefore, it can be concluded that the use of models is essential in the guided inquiry-based chemistry learning process. Therefore, the selection of models is very much considered so that no students misunderstand the concept or misconception. To minimize this misconception, the abstract concept model is fully represented with three levels of chemical representation, namely macroscopic,
symbolic and submicroscopic levels, learning without involving the three levels of chemical repentance found many problems.\[14\]

The model presented is explored to answer key questions. Key questions are at the heart of guided inquiry activities\[6\]. This key question guides students to explore the model. Key questions facilitate students to be active while learning a concept. These questions are related to each other and are made from low level cognitive to high level cognitive. At this stage the thinking ability of students will be challenged. When students have passed the exploration phase this means that students have also passed the concept formation stage. Because the concept is formed in line with students exploring the model.

In the experimental class each concept is explored with one or more models and guided by key questions. These key questions can lead students to learn independently, be active in group discussions and find concepts according to the steps of the student worksheet. Therefore the exploration and formation stage of the concept takes place well. Meanwhile, in the control class LKPD used was not equipped with models that could be analyzed by students. At the concept formation stage the key questions are conveyed by the teacher without being presented on the student worksheets used so that students find it difficult to find concepts independently and group discussions do not go well.

The application stage is the stage where students strengthen and expand the concepts that they have formed. At this stage students are given exercises and questions. Exercise gives students the opportunity to build confidence in simple situations and known contexts. Questions require students to analyze complex situations. Because the revised student worksheet aims to train high order thinking skills of students, then this question is given a question with a level of cognitive level analyzing (C4), evaluating (C5) and creating (C6).

In the experimental class students are helped by the existence of a guided inquiry-based LKPD that contains steps in finding and applying concepts to solve the problem given. Unlike the case with the student worksheet control class used only contains questions that confirm the results of the experiment and are not related to each other. So that quite a lot of students have difficulty in working on the problem.

The last stage is the closing stage. At this stage At this stage students draw conclusions, reflect on what they are getting and assess their performance. In this final stage students report the results to colleagues and teachers\[6\]. Representatives from the group report the concepts that they have got with the group. Meanwhile other groups were given the opportunity to provide responses and additions to the reports submitted by their friends.

In the experimental class, the delivery of the results of the discussion was more active and the learning material could be mastered by the students well. This is because learning using guided inquiry-based student worksheets guides students to discover and understand concepts. Whereas in the control class the concepts obtained by students are not well guided so that students still have difficulty in delivering the results of the discussion. After the conclusions are conveyed by the students, the teacher confirms the results of the discussion and rectifies the wrong concept.

References
[1] Kemendikbud. 2017. *Modul Pelatihan Kimia*. Jakarta: Kementerian Pendidikan dan Kebudayaan
[2] Heong, Y.M.dkk. 2011. The Level of Marzano Higher Order Thinking Skills Among Technical Education Students. *International Journal of Social and Humanity*, Vol. 1, No. 2
[3] Brookhart, S. M. (2010). How to Assess Higher Order Thinking Skills in Your Classroom. Alexandria: ASCD
[4] Demircioğlu, Gökhan, dkk. 2005. “Conceptual change achieved through a new teaching program on acids and bases” *Chemistry Education Research and Practice*. Vol 6 No.1.
[5] Straumanis, Andrei. 2010. “Process Oriented Guided Inquiry Learning”. Andrei Straumanis
[6] Hanson, David. M. 2005. “Designing Process-Oriented Guided-Inquiry Activities”. Pacific Crest.
[7] Aini, Faizah Qurratu. 2016. Development of Guided Inquiry Based Student Worksheet on the Chemical Equilibrium Topic for Chemistry Learning in 11th Grade. *International Conference on Teacher Learning and Development (ICLT)*, Malaysia
[8] Campbell D.T., Stanley J.C.,1963.*Experimental and Quasi Experimental Design for Research.*
[9] Hake. 2002. Relationship of Individual Student Normalized Learning Gains in Mechanics with Gender, High-School Physics, and Pretest Scores on Mathematics and Spatial Visualization. *Indiana University*.

[10] Irham, S. M., Mawardi dan Oktavia, B. 2016. The Development of Guided Inquiri Based Worksheet on Colligative Properties Solution for Chemistry Learning”. International Conference On Mathematics and Science Education

[11] Zamaluni, Allizar Ulianas, dan Mawardi Mawardi. 2018. “Development of Guided Inquiry Based Work Sheet with Class and Laboratory Activity on Chemical Bonding Topic in Senior High School” *International Journal of Chemistry Education Research*. Vol. 2 2 Iss. 2

[12] Repdayanti, Mawardi, dan Budhi Oktavia. 2018. The Development of Student Worksheets based on Guided Inquiry by Class and Laboratory Activity for Reaction Rate Material at the 11th Grade in High School. *International Journal of Progressive Sciences and Technologies (IJPSAT)*. Vol. 8 No. 2: 286-294

[13] Riduwan. 2013. Belajar Mudah Penelitian Untuk Guru-Karyawan dan Peneliti Pemula. Bandung: Alfabeta.

[14] Orgill, M dan A. Sutherland. 2008 “Undergraduate chemistry students’ perceptions of and misconceptions about buffers and buffer problems,” *Chem. Educ. Res. Pract*. Vol. 9 No. 2