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# The effectiveness of guided inquiry based colloid system modules integrated experiments on science process skills and student learning outcomes

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**Abstract.** Chemistry learning in senior high school is currently dominated by classroom activities. Laboratory activities have not been optimally carried out, because of the science process and student understanding skills have not been well developed. The purpose of this study was to reveal the effectiveness of using guided inquiry colloid system modules integrated experiments on science process skills and student learning outcomes. The type of this research was a quasi-experimental, with a Randomized Control Group Posttest Only Samples were obtained through simple random sampling technique, consisting of experimental class and control class. The experimental class learning using modules based on integrated inquiry inquiry experiment while the learning control class is conventional. From the data analysis, the average value of the ten indicators of the science process skills of the experimental class students was 80.0 (very high category) and the control class was 71.7 (high category) The average value of student learning outcomes of the experimental class was (80.9) which was significantly higher than the control class (60.6). From these findings, it can be concluded that the guided inquiry-based chemical equilibrium module integrated experiments was effective to improve science process skills and student learning outcomes. It is suggested to the chemistry teacher to use this module as an alternative in learning media.

## 1. Introduction

The colloidal system describes heterogeneous mixture in general must have at least one dimension in the range of 1-1000 nm [1][2]. The colloid system is a chemical matter learned in grade senior high school. Based on the curriculum syllabus of 2013, the students will learn the differences between colloid, solution and suspension, the types of colloid, the properties of colloids, the preparation of colloids, and the role of colloids in everyday life and industry.

Colloidal system matter consists factual, conceptual, and procedural knowledge dimensions which can be taught with various methods and teaching materials. In conveying the concepts of the colloidal system matter, it can be done through practical activity. Experimental method will provide opportunities for students to be involved in finding concepts, developing cognitive, affective, and psychomotor abilities so as that students will have better understanding of the concepts [3]. In addition, the experimental activity will make learning activities more meaningful because the experimental activities provide opportunities for students to be directly involved in observing



scientific processes, practicing scientific thinking skills, instilling and developing scientific attitudes [4]

Regulation of Education Minister No 59 of 2014 states that the chemistry learning more emphasis on job skills application / process science. Science process skills are the development of intellectual, social, and physical skills that originate from fundamental abilities which in its basic principles already exist in students [5]. The learning model that can be used in applying science process skills is a guided inquiry model. Learning using a guided inquiry model can make students actively involved during the learning process [6]. In addition, with the implementation of guided inquiry learning, students can develop the concepts that they have learned not only limited to the material recorded and memorized [7].

Guided inquiry learning consists of 5 stages called *orientation*, *exploration*, *concept formation*, *application*, , and *closure* [6]. By using a module that implements the guided inquiry model in learning activities, students can engage all their abilities to find the concepts systematically, critically, logically, analytically so that they can formulate their own findings [8] .

Based on research conducted by Bruck LB, and Towns MH (2008) and Megadomani (2011), it was concluded that experimental activity or guided inquiry-based experiment is one of the recommended methods in chemistry learning [9] [10]. In addition, some research regarding integrated experiment activities concluded that learning with integrated experiment activities effectively improves student learning outcomes in the cognitive domain [11] [12] [13].

Based on interviews with teachers at SMAN 5 Padang, experiment activities were not integrated into learning process. Experiment activities are often carried out after theoretical learning is taught. In the experiment activities, the students work based on instruction contained in the materials given by the teacher without thinking the reason for doing these stages. In addition, the learning materials have not been fully able to lead students to find their own concept. The experiment activities will become data collection and confirm the theory. So it takes a teaching material that can guide students to find their own concepts.

This study aims to reveal the effectiveness of using colloidal system module based guided inquiry integrated experimental and science process skill that have been compiled by Lidia Fitri on the learning outcomes of students of XI MIPA SMAN 5 Padang.

## 2. Research Method

Based on the problems and objectives that have been stated, this type of research was a *quasi-experimental* research (pseudo experiment). Quasi-experimental research is a research conducted if it cannot control all variables related to the sample [14]. The design of this research was *Randomized Control Group Posttest Only Design*. In this design there are two classes, the first class is experiment and the second class is control class. The experimental class is a class that uses a colloidal system module based guided inquiry integrated experiment and science process skills. Meanwhile the control class is a class that uses the chemistry book for XI grade which usually uses at school. The population in this study were all students XI grade of high school number 5 on 2017/2018. Sample determination was done by *simple random sampling technique*. This technique is a random sampling technique regardless of the strata where all members of the population have the opportunity to be sampled. Based on this technique, class XI MIPA 1 was obtained as the experiment class and class XI MIPA 2 as the control class.

This research was carried out in three stages, called the preparation stage, the implementation phase, the completion phase. On the preparation stage consisted determination of the location and schedule of the study, determination of population and sample, making the lesson plan for the colloidal system, making the test questions and the key answers, analyzing the test questions, making the final test questions, and preparing the final test questions. On the implementation phase, the experimental class used a guided inquiry-based colloid system module integrated experiment and science process skills while the control class used chemistry book for grade XI. On the completion

stage, the final test was carried out in both sample classes and then an analysis was carried out to draw conclusions.

The research instrument in this study was the final test of learning outcomes in the cognitive domain. This test was a *multiple choice* question with 5 answer choices. The final test of learning outcomes consisted of 25 questions derived from 40 test questions that have been tested for validity, reliability, difficulty index, and the power of the difference.

To test the validity of the hypothesis proposed, data analysis was carried out. The analysis carried out is a one-party hypothesis test [15]. To test the hypothesis, first the data is tested for normality and homogeneity.

Based on the results of the test for normality and homogeneity of the final test results, it was found that the two classes of samples were normal and had homogeneous variance. To test the hypotheses, it was calculated by the t-test.

### 3. Result and discussion

#### 3.1. Data Description

Assessment of learning outcomes is done by giving a final test consists 25 multiple choice question to both sample classes. Based on final test data showed that the highest score of the experiment class and the control class are 92. While the lowest score of the experimental class is 44 and the control class is 24. The average score both of these classes are respectively 80.9 and 60.6

#### 3.2. Data analysis

To find out the difference in the average of the two classes is a significant difference or not, the similarity test of two averages is carried out. The tests are the difference in the value of the two sample classes, normality test, homogeneity test, and t-test. The value of learning outcomes for both classes of samples is calculated so that the average value is obtained ( $\bar{X}$ ), standard deviation (S), variance ( $S^2$ ). From both sample classes, the data in Table 1 was obtained.

**Table 1.** Average Value, Highest Value, Lowest Value, Standard Deviation, and Second Variance of Sample Class

Class	N	The highest score	Lowest Value	$\bar{X}$	S	$S^2$
Experiment	31	92	44	80.9	11,487	131.96
Control	30	92	24	60.6	15,777	248.94

Table 1 shows that the the learning outcome of experiment class is higher than the control class. To find out whether there are significant differences in the two sample classes, a hypothesis test is conducted. However, first normality and homogeneity tests is done.

**3.2.1. Normality Test.** The data of learning outcomes from both of the classes were tested for normality using the Liliefors test. The results of the analysis of the normality test at the 0.05 significant level can be seen in Table 2.

**Table 2.** Results of Normality Test for Sample Class Final Test Results

Class	A	N	$L_o$	$L_t$	Distribution
Experiment	0.05	31	0.11326	0.15913	Normal
Control		30	0.09677	0.161760	Normal

Table 2 shows that the value of  $L_o$  is smaller than  $L_t$ . This shows that both classes of samples are normally distributed.

**3.2.2. Homogeneity Test.** To find out the two classes of samples have homogeneous variance or not the homogeneity test is done by using the F test. The results of the homogeneity test analysis at a significant level of 0.05 can be seen in Table 3.

**Table 3.** Homogeneity Test Results for Sample Class Final Tests

Class	N	$S^2$	$F_h$	$F_t$	Information
Experiment	31	131.96	1.88	1.89	Homogeneous
Control	30	243.94			

Table 3 shows that  $F_{\text{arithmetic}}$  is smaller than  $F_{\text{table}}$  so it can be concluded that the two classes have homogeneous variance.

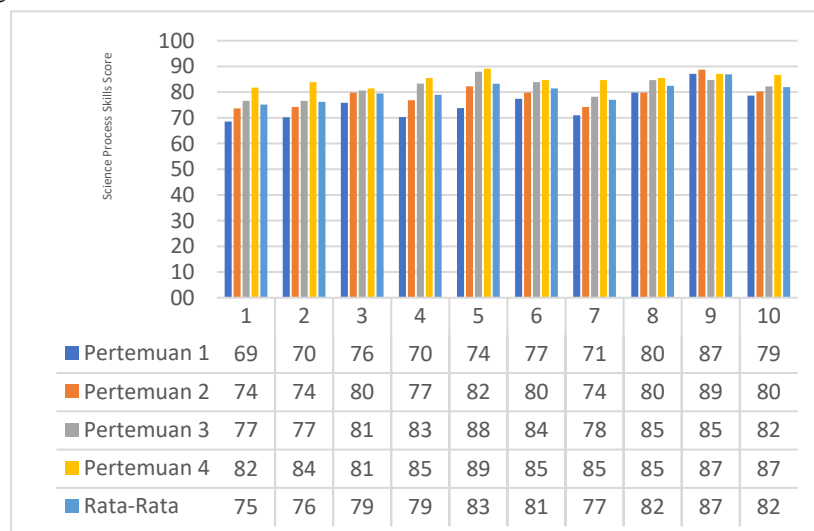
3.2.3. *t-Test*. Based on the results of the analysis of the normality test and the homogeneity test of both classes show that the two classes are normally distributed and have homogeneous variance. Therefore, t-test is used to test the hypothesis, the results of which are summarized in Table 4.

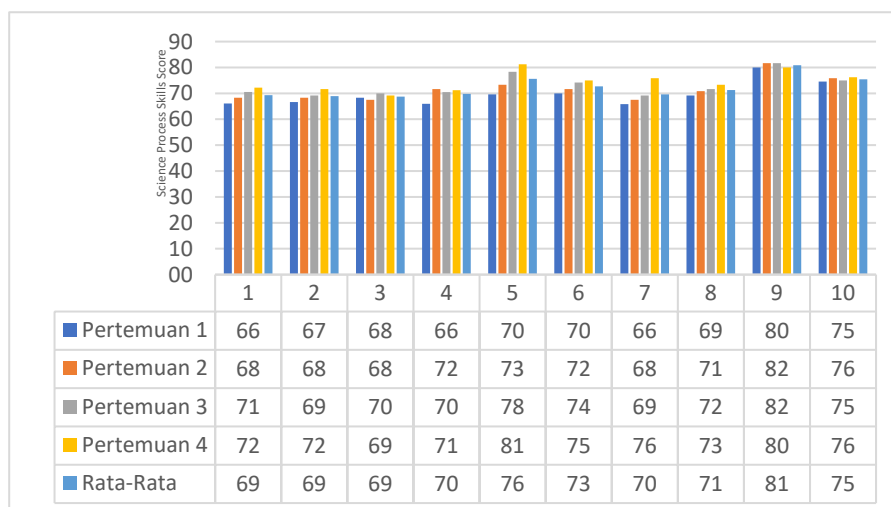
**Table 4.** Hypothesis Test Results on Sample Classroom Learning Outcomes

Class	N	S	$S^2$	$t_{\text{count}}$	$t_{\text{table}}$
Experiment	31	80.9	11,487	131.96	5.76
Control	30	60.6	15,777	248,94	

Table 4 shows that  $t_{\text{count}} = 5.76$  and  $t_{\text{table}} = 1,67$  so that  $t_{\text{count}} > t_{\text{table}}$  and  $H_0$  is rejected. So, it can be concluded that there are significant differences in learning outcomes in both sample classes on knowledge competencies.

In addition to assessing learning outcomes in the cognitive domain, assessment of science process skills is also carried out. Students' science process skills are assessed based on indicators of science process skills, namely 1) SPS-1 planning experiment, 2) SPS-2 asking questions, 3) SPS-3 formulating hypothesis, 4) SPS-4 using tools and materials, 5) SPS-5 observing, 6) SPS-6 classifying, 7) SPS-7 interpreting, 8) SPS-8 predicting, 9) SPS-9 applying the concept, 10) SPS-10 communicating. The results of the assessment of science process skills in the experiment class and control class can be seen in Figure 1 and Figure 2.

**Figure 1.** Average Score of Science Process Skills for Experiment Class



**Figure 2.** Average Score of Science Process Skills for Control Class

#### 4. Discussion

Based on the description and data analysis, it can be seen that there are differences in student learning outcomes in both sample classes. Learning outcomes of experiment class is higher than control class. Differences in learning outcomes are influenced by teaching materials used during the learning process. Learning in both sample classes, experimental class and control class, was carried out by applying the guided inquiry model. Learning using guided guidance models is student-centered learning, students work in small groups with individual roles to ensure that all students are fully involved in the learning process [16]. There are 5 stages in guided inquiry learning, called orientation, exploration, concept formation, application, and closing [6]. The difference between the two sample classes in this study lies in the teaching materials used in the learning process. The experimental class uses an integrated experimental inquiry-based module and science process skills that have been tested for validity and practicality by Lidia Fitri, S.Pd (2017) while the control class uses chemistry book for XI grade commonly used in school.

Learning using guided inquiry modules can attract students' interest in learning. This is due to the stages of learning contained in the guided inquiry-based module, namely orientation, exploration, concept formation, application, and closing. The orientation phase in the module is located in the delivery of indicators, learning objectives, and supporting material. The exploration phase is located in the presentation section of the practicum model and activities. The model described can be in the form of color images and sub-microscopic representation of the model. The concept formation stage lies in the critical question. The application stage is located in the training section and the closing stage is located in the concluding section.

The critical questions contained in the inquiry-based module are the most important part of inquiry learning. Critical questions can lead students to think critically, analytically so that they can help students to develop their own concepts and make conclusions. In addition, key questions also guide students to find concepts in the learning process [17]. This is in accordance with the opinion of Hanson that critical thinking question are the heart of guided inquiry learning, student actively working to learn new content and develop process skills.

In this guided inquiry module, critical thinking questions are designed based on indicators of science process skills (SPS). The indicator science process skill are observing, classifying, classifying, interpreting, communicating, asking questions, submitting hypotheses, designing experiments, using tools and materials, applying concepts, and conducting experiments [8] [18] [19] [20]. In addition, critical thinking questions are made interconnected and arranged from a low level to

a higher level so that students can develop answers based on what they have found in previous information, what they already know based on answers of the previous questions. The guided inquiry module that integrates experiment on the material of the colloidal system can increase students interest in learning independently and finding their own concepts [21]

Different from experiment class, the book was used in the control class didn't contain the stages of guided inquiry learning so students have difficulty in learning. In addition, the book also didn't contain the critical thinking questions that can guide students in building concepts. The questions contained in the printed book are only confirmation of the results of the experiment, questions that are not interconnected with each other, questions that do not guide students in finding concepts, so that students have difficulty in developing understanding of concepts.

The high learning outcomes of experimental class students were significantly driven by the use of integrated inquiry inquiry-based modules and process skills. By using the module student is guided to think critically by answering critical questions about the model presented. The high learning outcomes of students in the experimental class are also caused by the use of modules that can guide students to find new knowledge relationships obtained with the previous ones and see the relevance and application of concepts. So that experimental class students gain more meaningful experiences and concepts will be more embedded in their minds [22] [23].

With the strong information attached to students' memory, it will also affect the acquisition of student learning outcomes. Beside of that students can learn to solve problems objectively, critically, openly and collaboratively. This will have a positive effect on scientific attitudes, skills and student learning outcomes. This is also supported by Salamah (2017) that active involvement of students can increase science process skill and the direct experience will improve student memory so that knowledge will stay longer. In addition, research conducted by Bilgin and Myers found that learning using a guided inquiry learning model can make students more understand the concepts easily and improve the effectiveness of interaction, build teamwork, and interest through highly structured group collaboration [22]

Experiment activities that are integrated with learning activities will help students better understand the concept. In an integrated experiment activity, students learn from the fact of the data obtained from lab activities, analyze data on the lab, generalize and concludes what they have found. The new concepts are formed through own experience so that they will last longer in students's memories [12]

Learning with module based guided inquiry integrated experiment and science process skills can also increase the science process skill of students. It can be seen in the results of the science process skill assessment of the experiment class and control class. The experiment class obtains a higher score than the control class. The high score of science process skill of students will be in line with the high learning outcomes in the cognitive domain. Nworgu and Otum (2013) concluded that learning using guided inquiry models has an effect on improving science process skills and providing opportunities for students to use various sources of information and ideas in understanding and solving problems [24]. Science process skill approach will give students the opportunity to observe, classify, interpret and communicate the data that they have found during the learning process. This will help students understand the material so that it becomes a long time memory. This is in accordance with Hesbon's research (2014), that the science process skills approach in learning can facilitate students to get higher learning outcomes than other approaches [25].

Guided inquiry-based and integrated experiment modules and science process skills provide guidance to students in finding concepts through models, key questions, exercises, and problem solving. This makes the experimental class have several transcendence than the control class 1) making the experiment class students more active than control classes, because students are required to solve their own problems with the help of key questions, 2) Having the ability to think critically and analytically students better than the control class, 3) having higher academic achievement than the control class, 4) Having higher science process skills than the control class

Constraints experienced during conducting research are less conditioned students at the first meeting so that learning is slightly disrupted. The next obstacle is poor timing at each stage of learning

at the first meeting. So that for the next meeting, the teacher conditions students and provides a time limit for each stage of learning so that learning objectives can be achieved.

## 5. Conclusion

Based on the results of research and data analysis that has been carried out, it can be concluded that using the module based guided inquiry integrated experimental and science process skills is effective to improve the student learning outcomes and science proses skills in colloidal system topic. It can be seen from the learning outcomes of experiment class (using integrated guided inquiry based experiments and science process skills) is higher with an average of 80.9 than the control class (using book without based guided inquiry commonly used in schools) with an average of 60. The average of science process skill from experiment class is also higher with average 82 than control class with average 75.

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