Journal of Physics: Conference Series

PAPER • OPEN ACCESS

Effectiveness of chemical equilibrium module based guided inquiry integrated experiments on science process skills high school students

To cite this article: Andromeda *et al* 2019 *J. Phys.: Conf. Ser.* **1185** 012152

IOP Conf. Series: Journal of Physics: Conf. Series **1185** (2019) 012152 doi:10.1088/1742-6596/1185/1/012152

Effectiveness of chemical equilibrium module based guided inquiry integrated experiments on science process skills high school students

Andromeda*, Iryani, Ellizar, Yerimadesi and W P Sevira

Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang, Jl. Prof Hamka, Padang 25131, Indonesia

*opetsaidir@gmail.com

Abstract. The improvement of senior high school students skill in finding the concept by using module based on guided inquiry integrated experimental activities in the classroom was investigated. The Chemical Equilibrium material was chosen since the module has been estatabilished. This study aims to reveal the effectiveness of the use of integrated chemical equilibrium module-based on guided inquiry integrates the experiment to the study and science process skills (SPS) students. The experimental class which is learn by using the module-based guided inquiry integrates the experiment, whereas the control class by coventions system. From the data analysis, the mean value of SPS of experimental class is 83,1 (very high category) higher than control class that is 72,7 (high category). While the mean score of experimental class (81,3) was higher than the control class (77,4). From these findings it can be concluded that the chemical equilibrium module based guided inquiry integrated the experiment was effective in improving science process skills and student learning outcomes. Therefore, it was recommended for chemistry teachers to use this module as an alternative of learning chemistry in high school.

1. Introduction

Chemical equilibrium explains the conditions in which the forward reaction rates and return rates are same and where the concentrations of reactants and products no longer change over time [1] [2]. Chemical equilibrium is the material taught in the odd semester XI class for senior high school. In this subject, the students should be able to analyze the factors that influence the shift in equilibrium direction, ie concentration, temperature, volume, and pressure, and able to determine the quantitative relationship between reactants with the reaction result of an equilibrium reaction through experiment (KD 4.8 and 4.9 Chemical Equilibrium Curriculum 2013). In the delivery chemical equilibrium concept, in accordance with the above KD then in learning this material requires experimental activities. Experimental activities can provide direct observation of the symptoms or processes of science, train the ability to think scientificaly, inculcate and develop a scientific attitude. In addition, experimental activities can provide more meaningful and profound learning [3]. Several studies have concluded that experimental / experimental experience in learning can improve student achievement and learning outcomes [4] [5] [6] [7].

Based on observations and interviews with several chemistry teachers, as well as some students at state senior high school in Padang City, information is obtained that the experimental activities in the school have not been implemented optimally. Generally, the experimental activities are carried out

IOP Conf. Series: Journal of Physics: Conf. Series **1185** (2019) 012152 doi:10.1088/1742-6596/1185/1/012152

separately (not integrated), aiming to confirm the concept not to find. The results of the analysis of teaching materials used in the learning concluded that generally schooled using job sheet that have not integrated experimental activities in its job sheet. According to student's job sheet used is not interesting because it contains a lot of verbal information. It was not yet found using modules that integrate experimental activities. All of these things cause students' motivation to study chemistry is low.

The low of minister education number 59 of 2014 states that the learning chemistry is a learning that emphasizes the skills of the science process (SPS). SPS is a process for performing activities related to science. SPS gives students the opportunity to discover the facts and connect the concepts, through activities or experiences [8]. In addition, SPS is a learning approach that gives students the opportunity to discover concepts by interacting with concrete objects [9]. SPS can also help students to provide meaningful learning experiences as they can also develop higher-order thinking [10].

Gagne et al, states SPS is seen as a problem-solving skill in which problems go through a systematic process undertaken to be solved [11]. SPS is important for teaching ways to solve the problems. Students need good process skills when conducting scientific inquiry and during the learning process [12] [13]. Indicators are often used as a reference in the process of understanding the concept of science conducted by students that is, (1) interpreting, (2) example, (3) classify, (4) summarize, (5) guess, (6) compare, (7)) explains, (8) formulates the hypothesis, (9) observes, (10) implements the concept, (11) formulates the problem, (12) asks questions, (13) plots the experiment and (14) communicates. [8] [14 [[15] [16].

Scientific process skills can be developed by applying the inquiry learning model. Inquiry is a series of learning activities that involve all students' abilities to the fullest to seek and investigate critically, systematically, logically and analytically, so that students can find the concept independently [17]. Guided inquiry is one of the inquiry learning models, which requires students to conduct a series of investigations, explorations, searches, experiments, searches, and research. This learning is centered on students, students can work in small groups [18] [19].

Several studies have shown that guided inquiry learning is effective in providing meaningful learning, improving students' skills in understanding concepts, improving learning outcomes and science process skills [20] [21] [22]. Guided Inquiry-based experimental or practicum is one of the most recommended learning methods in chemistry learning [23].

In carrying out effective and efficient learning is needed teaching materials that can help students and teachers in carrying out learning activities. One of the teaching materials that can be used in learning and can make the students active and independent is the module [24]. Modules are teaching materials that can stimulate learning motivation, as well as students' intrinsic motivation [25] [26]. The use of modules in chemistry learning gives good results to student learning outcomes [27].

Based on preliminary research conducted (2017), we have produced a valid and practical experimental guided inquiry based chemical equilibrium module with very high level of validity and practicality. This module has not been tested for its effectiveness on student learning outcomes and student process skills [28]. Based on the above problems, this study aims to reveal the effectiveness of guided inquiry-based equilibrium chemistry module integrated experiments on students' learning outcomes and science material process skills.

2. Research methods

This research type is quasi experiment research. The research design used is Randomized Control Group Posttest Only Design. There are two classes of sample that is experiment class and control class. The experimental class is uses integrated inquiry based chemistry equilibrium module is integrated experiment while the control class using the book of chemistry class XI Unggul Sudarmo. The study population is all students of class XI science of senior high school 1 Padang in the academic year 2017/2018 consisting of 8 classes. Sampling is done by simple random sampling technique. Obtained class XI science 4 as experimental class and class XI science 1 as control class.

This research was conducted in three stages, namely preparation phase, implementation phase, and completion phase. The preparation stage are determining the place and the schedule of the study, determining the population and the sample, specifying the experimental class and control class,

IOP Conf. Series: Journal of Physics: Conf. Series **1185** (2019) 012152 doi:10.1088/1742-6596/1185/1/012152

preparing an integrated inquiry-based integrated chemical equilibrium module, preparing the Chemical Equilibrium Study Plan for the experimental class and control class, make a grid about the test, make a test question and answer the key, analyze the test questions, and prepare the final test questions. The implementation stage is experimental learning that was conducted using experimental integrated equilibrium-based chemical equilibrium module, while in the control class using grade XI excel chemical book Sudarmo on chemical equilibrium material. At the completion stage, a final test is conducted on both sample classes, followed by data processing and the last is to draw conclusions.

The research instruments used in this study are the test of learning outcomes for knowledge competence and observation sheets for SPS activities. The competency test of knowledge is given in accordance with the subject matter that has been given to the two sample classes. In order to have a good test, so we tested the validity of the test, test reliability, difficulty index, and different power questions a were done. From the analysis of 40 items about the test obtained 25 items that meet the standard test requirements.

The results of the SPS evaluation and module filling data were evaluated and processed by percentage technique [29], while the difference between the experimental class and control class was done by examining the similarity of two two-party test averages [30]. However, the data were first tested for normality and homogeneity test. The result of the normality and homogeneity test of the final test result showed that both samples were normally distributed and homogeny so that the data analysis was done by t-test.

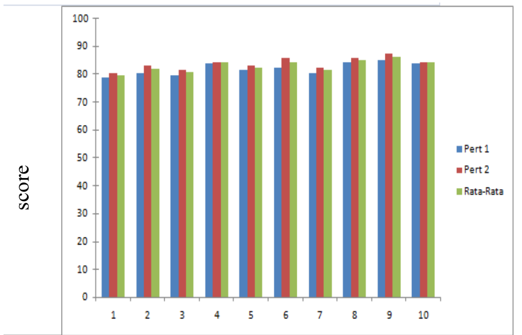
3. Results and discussion

3.1. Description of data

Data on student learning outcomes was obtained from final test scores performed at the end of the learning in both sample classes. The final test is an objective test with 5 multiple choices of 25 items. In the experimental class it were obtained that the lowest value of 64 and the highest value 100. As for the control class the lowest value of 60 and the highest value 96. The average value of SPS experiment class is 83.1 with very high category, while for the control class is 72.6 with high category.

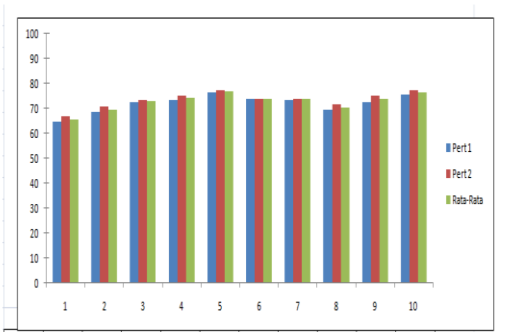
3.2. Results data analysis

3.2.1. Analysis of result. There are 10 SPS indicators assessed in this study, namely (1) planning the experiment, (2) asking questions, (3) formulating hypotheses, (4) using tools and materials, (5) observing, (6) classifying, (7) interpreting, (8) predicting, (9) applying the concept, and (10) communicating. The result of student SPS assessment analysis is shown in Figure 1.



Pert 1	79	80,5	79,75	84	81,75	82,5	80,5	84,5	85,25	84
Pert 2	80,5	83,25	81,75	84,5	83,25	86	82,5	86	87,5	84,5
Rata-Rata	79,75	81,87	80,75	84,25	82,5	84,25	81,5	85,25	86,37	84,25

Experimental Class



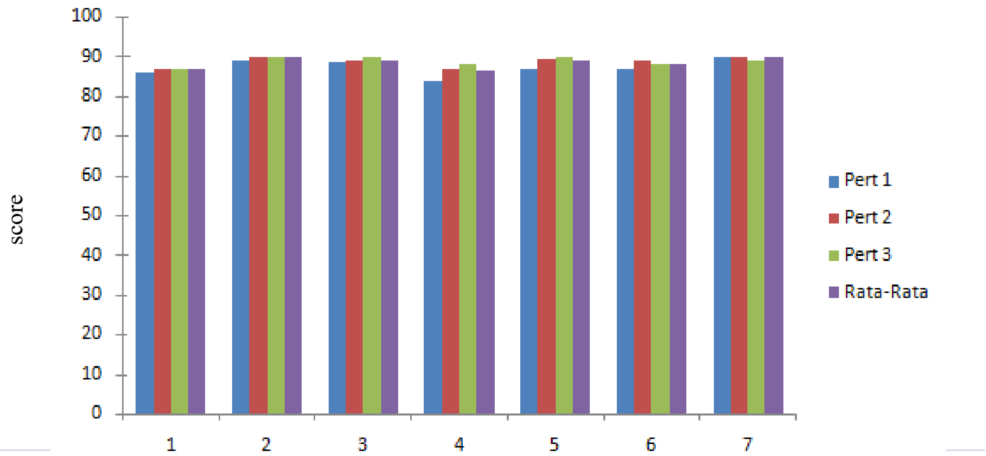
Pert 1	64,5	68,5	72,5	73,25	76,5	74	73,25	69,25	72,5	75,75
Pert 2	66,75	70,75	73,25	75	77,25	74	74	71,75	75	77,25
Rata-Rata	65,5	69,6	72,9	74,1	76,9	74	73,6	70,5	73,8	76,5

Control Class

Figure 1. Average Grades of Student-grade SPS in Exsperiment Class and Control Class at SMAN 1 Padang. (Pert1 = meeting 1, Pert2 = meeting 2, rata-rata = average)

From Figure 1, it can be seen that the results of the SPS students' assessment on the two sample classes for the 10 SPS indicators, is 83.1 for the experimental class (very high category) and 72.7 for the control class in the high category. These results indicate that the modules structured are very effective in supporting the improvement of student SPS.

3.2.2. Assessment results of module filling. The effectiveness of the module is also supported by the value data of the student's answer analysis in answering all questions in the module (job sheet) .Questions in the module are arranged based on 10 SPS indicators. Assessment of the results of the analysis is varies as follows : (1) answer the pre-lab questions, (SPS-1 indicators, and SPS-2), (2) formulate hypotheses, (SPS-3 indicators), (3) fill in the observation table (SPS-5, and SPS-6), (4) answer CTQ (indicator SPS-7), (5) do exercises / answer post-lab questions (indicator SPS-8), (6) answer questions on LK (indicator SPS-9), and (7) make a conclusion (indicator SPS-10). The result of module filling analysis is shown in *Figure 2.*



	1	2	3	4	5	6	7
Pert 1	86	89	88,5	84	87	87	90
Pert 2	87	90	89	87	89,5	89	90
Pert 3	87	90	90	88	90	88	89
Rata-Rata	86,7	89,7	89,2	86,3	88,8	88	89,7

Figure 2. Average Answer Values Questions on Student Module of SMAN 1 Padang. (Pert1 = meeting 1, Pert2 = meeting 2, Pert3 = meeting 3, rata-rata = average)

From Figure 2 it can be seen that for SMAN 1 Padang the result of the evaluation of the student's answer on the module in each activity average is (88,5) in very high category, above KKM is 80. These results show that modules compiled based on experimental integrated learning guided inquiry model are very effective in supporting improved learning outcomes and student SPS

3.2.3 Student learning outcomes. The data analysis was done through two equality test equations, to see whether the mean of the two sample classes was different significantly. Starting from the different values of the two sample classes, normality test, homogeneity test, and t test. The value of the students' learning outcomes in the two sample classes was calculated to obtain the mean values ($\bar{x}$), standard deviation (S), and variance (S^2). From the two sample classes we get the data in Table 1.

Table 1. Average, Highest, Lowest, Standard deviation, and Sample Class Variance

Class	N	The highest score	Lowest score	$\overline{X}$	S	S^2
Experiment	36	100	64	81.3	10.518	110.629
Control	31	96	60	77.4	12.24	149.92

From Table 1, it can be seen that the students' learning outcomes of the experiment class are higher than the control class. To test whether there is a significant difference between the experimental class and the control class, hypothesis testing is performed. Previously, the normality test and homogeneity test were done at first.

3.2.3.1. Normality test. From the experimental class study and control class, normality test was conducted in both sample classes using Liliefors test. A complete normality analysis at a real level of 0.05 as listed in Table 2.

Table 2. Normality Test Result of The Sample Class Final Test

Class	α	N	L_o	L_t	Distribution
Experiment	0.05	36	0.112811	0.147667	Normal
Control		31	0.9898	0.15913	Normal

Table 2 shows that both sample classes have Lo <Lt values at a real level of 0.05. The data of the final test results of the two sample classes were normally distributed in this study.

3.2.3.2. Homogeneity Test. To determine wether the two sample classes have homogeneous variance or no homogeneity test using F test for both sample classes. The homogeneity test analysis can be summarized in Table 3.

Table 3. Results of Homogeneity Test for Final Tests Sample Classes

Class	N	S^2	F_h	F_t	Information
Experiment	36	110,629	1,05	1,84	Homogeneous
Control	31	149,92			

From the analysis of data that has been done, shows the variance performed on the final test data of both classes of samples obtained $F_{count} < F_{tabel}$. So it can be concluded that both sample classes have homogeneous variance.

3.2.3.3. Hypothesis testing. From normality test and homogeneity test of experimental class and control class shows that both of two classes are normally distributed and have homogeneous variance. Therefore, to test the hypothesis used t-test and hypothesis test results data summarized in Table 4 below.

Table 4. Hypothesis Test Results on Classroom Sample Learning Results

Class	N	$\overline{X}$	S	S^2	t_{count}	t_{tabel}
Eksperiment	36	81,3	10,518	110,629	5,72	1,66
Control	31	77,4	12,24	149,92		

Table 4 shows that $t_{count} > t_{table}$, where $t_{count} = 5.72$ and $t_{table} = 1.66$, so H0 is rejected and the research hypothesis is accepted at the real level of 0.05. It can be interpreted that there are significant differences in learning outcomes of knowledge competence for both sample classes.

3.3. Discussion

Based on the description and data analysis obtained, it can be seen that the difference of the students' learning outcomes of two sample classes, where the learning outcomes in the experimental class were significantly higher than the control class. It caused by the integration with the experience of practicum can develop students' skills following a process, observing an object, analyzing, finding, and drawing their own conclusions about a particular object or concept. The results of this study are influenced by the teaching materials used during the learning process, because the control variables in this study are teachers time, curriculum, materials and learning models in both classes of samples. The learning model used is guided inquiry learning model. The guided inquiry learning model is a student-centered learning model. The students work in small groups with individual roles to ensure that all students are fully engaged in the learning process that makes students understand and remember longer. [31] The guided inquiry learning model consists of five stages, namely orientation, exploration, concept formation, application and covering [32]. The modules are designed based on the guided inquiry learning stage according to Hanson (2005).

The experimental class learning by using an integrated inquiry-based integrated inquiry module can attract students' interest in learning, since the module is structured based on the guided inquiry stage of Hanson (2005). At the orientation stage, an information is presented with respect to the previous material related to the chemical equilibrium material. The exploration stage in module of laboratory activity and model. The concept forming stage is the stage of the students relating the facts of the experimental results to the submicroscopic illustrations present in the module with critical questions. At the application stage students do the exercises and the closing stage on module is the stage of making conclusions. The orientation stage is an early stage to prepare learners in learning by providing motivation, building interest and raising curiosity. Critical questions are designed based on the scientific process indicator because the purpose of this learning module is to improve the science process skills of students. Ten SPS indicators were observed in the learning using this module are: (1) planning the experiment, (2) asking questions, (3) formulating hypotheses, (4) using tools and materials, (5) observing, (6) classifying, (7) interpreting, (8) predicting, (9) applying the concept, and (10) communicating.

The guided inquiry instruction guided in presented and the critical questions made can lead students to find concepts on chemical equilibrium materials. This is in accordance with the critical questioning function (critical thingking question) in guided inquiry learning is a question that can guide students in exploring the model.

Unlike the case with teaching materials used in the control class, used the book of chemistry class XI by Unggul Sudarmo. In this book, there is no critical question but, there are only questions that confirm the concept, the questions are not related to each other, the questions that do not guide students in finding a concept, so students will have difficulty in building conceptual understanding.

In the experimental class, with the use of integrated guided inquiry-based modules and experimental science process skills in group learning systems, students can work together to build their understanding and knowledge, so that students are easier to remember and understand [32]. It happen when students answer the critical questions. Students work together and discuss in answering critical questions. Thus, learning becomes more effective. This is in accordance with Hanson's opinion [33], which suggests that learning becomes more effective when students work together with many discussions both within groups and between groups.

Students using guided inquiry-based modules integrate students 'experimental learning while doing themselves in discovering the learned concepts so that students' science process skills develop well, students will gain more meaningful experience and stick in their minds. This will have an impact on improving SPS and student learning outcomes. Besides, students can learn to solve the problems objectively, critically, openly and cooperatively. In the experimental class, when students do the exercises and convey the results of the discussion (when confirmation from the teacher), the students look enthusiastic in expressing the group's conclusions. This is in accordance with previous studies conducted by Nworgu L. N., and Otum V. V. [34], concluding that the effects of inquiry are guided by

Analogy Instructional Strategy on the mastery of science process skills in biology learning will encourage students to perform well and reduce the gap among students.

The high learning outcomes of students 'knowledge competence in the experimental class is also evident from the students' ability to answer C3 (application) and C4 (analyze) questions. Based on the calculation, it is found that the experimental class students more answer the questions of C3 and C4 than the students in the control class in the experimental class, 81.0% C3 and 85.0% C4 while in the control class, 76.1% C3 and 79.0% C4.

Assessment of student learning outcomes in the 2013 curriculum is not only on knowledge competence but also on an attitude and skill competency assessment. Assessment of attitude and skill competencies are conducted during the learning process by the observer based on the observation sheet provided. The high learning outcomes of the students in the experimental class significantly compared to the students' learning outcomes in the control class are also seen in the affective and psychomotor competencies this is because the guided inquiry-based module integrated experiments and science process skills in the learning process, it gives the opportunity for the students to participate more actively in the learning process compared to the control class. Students are active in making observations, processing data and answering critical questions. Wolff and Anita [35] explain that science process skills are defined as skills that help to learn, help to find discoveries as well as methods and methods of researching, keep all students active, increase student responsibilities, and help them to understand practical studies, raise awareness for take responsibility for their own learning.

The guided inquiry-based integrated inquiry module provides guidance through models, critical questions, and exercises. This makes the experimental class has several advantages of the control class as follows: 1) Make the experimental class students more active than the control class, because learners are required to solve their own problems with the help of critical questions. 2) The experimental class students have better science-process skills than the control class. 3) Has a higher cognitive value than the control class.

4. Conclusion

Based on the results of research and data analysis, it can be concluded that the use of guided inquiry-based equilibrium module integrated experiments effectively in improving student learning outcomes and skills of high school students. The mean score of SPS students in the experimental class was higher (83.1 with very high category) than control class (72,6 with high category). The mean value of the students' learning outcomes of the experimental class was also significantly higher (81.3) than the control class (77.4).

Acknowledgement

The authors thank to UNP for financial support throug hibah PPT-DIPA 2017-2018 for this work.

References

[1] Chang, Raymond 2008 *General chemistry, the essential concepts, Third Edition*. New York: Mc Graw Hill
[2] Brady James E. & Fred Sanese 2009 *Chemistry matter and its changes 5th edition* : Jhon Wiley and Sons, Inc
[3] Astuti, Rina 2012 *Jurnal Inkuiri*, **1(1).**
[4] Hofstein, A and Lunetta V.N., 2003. *Science Education Research* **22,** 28-54
[5] Hofstein, Avi dan Rachel Mamlok-Naaman 2007 *Chemistry Education Research and Practice e journa*l. **8(2)** 105-107**.**
[6] Yeung, A., S. M. Pyke, M. D. Sharma, S. C. Barrie, M. A. Buntine, K. B. Da Silva, S. H. Kable, & K. F. Lim 2011 *International Journal of Innovation in Science and Mathematics Education* **19 (2)** 51-72.
[7] Andromeda, Bahrizal, & Zahara, A 2016 *Jurnal Eksakta,* **1(17)** 45-51
[8] Tawil, M. & Liliasari. 2014. *Keterampilan-keterampilan sains dan implementasinya dalam*

pembelajaran IPA. Makasar : UNM
[9] Majid, Abdul. 2014. *Pendekatan ilmiah dalam implementasi kurikulum 2013*. Bandung : PT Remaja Rosdakarya.
[10] Germann, P. J., & Aram, R. J 1996 *Journal of Research in Science Teaching*, **33(7)** 773-798
[11] Rose Amnah Abd Rauf, Mohamad Sattar Rasul, Azlin Norhaini Mansor, Zarina Othman & N. Lyndon 2013 *Asian Social Science*, **9(8)** 2013
[12] Harlen, W 1999 *Assessment in Education: principles, policy & practice*, ***6*(1)** 129-144.
[13] Harlen, W. 2000 *Assessment in Education*, ***6*(1)** 129-144.
[14] Rezba, R.J., Sprague C., Mc Donnough J.T., & Matkins J.J 2007 *Learning and assessing: science process skill*., kendall/Hunt Publishing Company
[15] Poppy 2010 *Keterampilan proses dalam pembelajaran IPA*, Pusat Pengembangan dan Pemberdayaan Pendidikan dan Tenaga Kependidikan Ilmu Pengetahuan Alam
[16] Devi, P.K 2010 *Keterampilan proses dalam pembelajaran IPA untuk guru SMP*, pusat pengembangan dan pemberdayaan pendidik dan tenaga kependidikan ilmu pengetahuan alam (PPPPTK IPA), Jakarta
[17] Gulo, W 2002 *Strategi belajar mengajar*. Jakarta: PT Grasindo.
[18] Abidin, Yunus 2014 *Desain sistem pembelajaran dalam konteks kurikulum 2013*. Bandung: Refika Aditama
[19] Straumanis, Andrei 2010 *Classroom implementation of process oriented guided inquiry learning*, A practical guide for instructor
[20] Bilgin, Ibrahim 2009 *SRE*, ***4 (10)*** 1038-1046.
[21] Gupta, Tanya 2012 *Guided-inquiry based laboratory instruction: investigation of critical thinking skills, problem solving skills, and implementing student roles in chemistry*. Disertasi diterbitkan. Ioawa: Iowa State University.
[22] Parappiliy, Maria B., Salim Siddiqui, Marjan G. Zadniq, Joe, & Lisa Schmidt 2013 *International Journal of Innovation in Science and Mathematics Education*, **21(5)** 42-53**.**
[23] Megadomani, Aritta 2011 *Proceedings of the 2nd International Seminar on Chemistry, Universitas Pendidikan Indonesia, Jatinangor*, 24-25 November.
[24] Hosnan, M 2014 *Implementasi Saintifik dan Kontekstual dalam Pembelajaran Abad 21*. Bogor: Ghalia Indonesia
[25] Ellizar, Bayharti, and Andromeda 2013 *Prosiding Semirata FMIPAUniversitas Lampung*: **117-124**
[26] Vaino K, Jack H and Miia R 2012 *Chemistry Education Research and Practice.* **13** 410-419
[27] Yerimadesi, Ananda, P., dan Ririanti 2017 *Jurnal Eksakta Pendidikan (JEP).* **1** 17-23
[28] Sintya Delvira, Andromeda*, dan Fajriah Azra 2017 Development of integrated inquiry-based chemical equilibrium module integrated experiments and skills of science process for high school students. *Skripsi*
[29] Riduwan *2015 Dasar-dasar statistika*. Bandung: Alfabeta.
[30] Sudjana 2005 *Metode statistik.* Bandung: Tarsito
[31] Carin, Arthur A 1997 *Teaching science through discovery, 8th edition.* Ohio: Merrill Publ. Co
[32] Straumanis, Andrei 2010 *Process Oriented Guided Inquiry Learning*: 1
[33] Hanson, David. M 2005 *Designing Process-Oriented Guided-Inquiry Activities*. In Faculty Guidedbook: A Comprehensive Toiol For Improving Faculty Performance. Ed. S Beyerlein and D. K. Apple. Lisle, IL: Pacific Crest
[34] Nworgu L.N., dan Otum V.V 2013 *Journal Education and Practic. ISSN 2222-1735(paper). ISSN 2222-288X (online*). **4(27)**
[35] Wolff M., & Anita R 2006 *Journal of Research in Science Teaching*. **30 (2)**