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Effectiveness of acid-base modules based on guided discovery learning for increasing critical thinking skills and learning outcomes of senior high school student

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Abstract. The goal of this study was to reveal the level of effectiveness of acid-base modules based on Guided Discovery Learning (GDL) on Critical Thinking Skills (CTS) and student learning outcomes in chemistry learning at senior high school. Module effectiveness was determined through quasi-experimental research with a randomized control-group pretest-posttest design. The sample consisted of 32 students as an experimental class and 35 students as a control class. The instrument used consisted of CTS test, pre-test and post-test. Student CTS test were analysed by percentage techniques and improvement of learning outcomes with N-Gain assisted SPSS software 25. The average CTS score of students found was 87.93% with very effective categories. N-Gain experimental class was 0.8 (high) that was significantly higher than that of control 0.69 (moderate). Both classes were normally distributed and homogeneous, and the t-test obtained $t_{count} > t_{table}$. The research findings show that the use of acid-base modules based on GDL can improve CTS and student learning outcomes in chemistry learning at senior high school.

1. Introduction

Learning materials are one of the important components in learning activities, because by using learning materials students can be guided independently. Now days, the availability of learning materials is still very limited in schools. Teachers should prepare learning materials that can guide students to active and independent learning. Module is one of learning material that guide student in defiantly and teachers can act as facilitators.

The research results showed that the use of modules can stimulate students' intrinsic motivation to learn chemistry. Intrinsic motivation of students who learn chemistry using modules is significantly higher than conventional learning (without modules) [1]. The use of modules in chemistry learning can also increase student activity and learning outcomes, such as in chemical equilibrium methods [2] and colloidal systems [3].

The module developed is based on the syntax of the discovery learning model, which is more helpful for the teacher in guiding students to learn, because it is in accordance with the steps of science learning. This module help teacher easily guides students in finding new knowledge and students become more

guided in active learning. Discovery learning-based chemical modules can improve student learning outcomes, such as in buffer solution material [4], salt hydrolysis [5], and electrolyte and non-electrolyte solutions [6]. This is because discovery learning is an instructional model that focuses on activeness and learning opportunities for students, directing students to build their own knowledge by experimenting on a domain, and deducing conjectures from the results of the experiment [7]**.**

Discovery learning has a positive effect on student success and perceptions of inquiry learning skills [8]. However, the application of this model has not been effective in West Sumatra, Indonesia. Teachers were still having difficulties to guide students in the second stage which is the problem statement of the discovery learning model. The problem determination is the stage, which students are asked to identify and formulate the problems that got from the stimulation stage. Reality in the field, generally senior high school students have not been able to identify and formulate the problems that they meet based on the stimulation stage delivered by the teacher. This problem affects the next stage of discovery learning, and students have difficulty formulating hypotheses and proving the truth of the hypothesis [9].

This data show that discovery learning cannot be applied to senior high school students, because senior high school students still need teacher guidance. Guided discovery learning models is better suited to the characteristics of high school students. To support the application of guided discovery models in the learning process, teachers need to provide learning materials, such as modules to help students learn both independently and in groups. Guided discovery is most effective for student centred learning [10] and in facilitating the achievement of student learning outcomes [11].

Results of previous studies showed that it has been found that acid-base modules based on guided discovery learning are valid and practical with very high categories of validity and practicality [12]. However, module effectiveness on critical thinking skills (CTS) and student learning outcomes have not been studied. Therefore, this study continued to reveal the effectiveness level of acid-base modules based on guided discovery learning on CTS and improvement of learning outcomes of high school students, so that this module can be used in real learning in high school.

2. Methods

The effectiveness test of using acid-base modules based on guided discovery learning is done through quasi-experimental design with randomized control group pretest-posttest design. In this research design, a group of research subjects from a population was used, and then randomly grouped into two groups of sample classes, namely the experimental group and the control group.

The experimental class was given treatment and control class without treatment, and in both classes the same test was conducted (pre-test and post-test) [13]. The control class was taught by conventional and experimental classes using acid-base modules based on guided discovery learning. The study population was all students of grade XI science class in Public Senior High School 12 Padang, Indonesia, 2017/ 2018 school year. Sampling was done by purposive random cluster sampling technique and was selected in class XI science class 1 as the experimental class and XI science class 2 as the control class. The research instrument used consisted of: (1) activity sheets and student worksheets on the module to measure student CTS and (2) learning outcome test sheets (pre-test and post-test) to measure improvement in student learning outcomes. Student CTS data were analysed by percentage techniques using equation 1 and the results obtained were interpreted using Riduwan criteria such as in Table 1 [14].

$$\%\ \text{Critical Thinking Skills} = \frac{\text{Scores Gained}}{\text{Total Score}} \times 100\% \quad (1)$$

Test questions used is a problem that is valid, reliable, and has a different power and good difficulty index. The increase in student learning outcomes is determined by the normalized gain (N-gain) formula (equation 2) and interpreted using the Hake (1999) classification [15].

$$\text{N-gain} = \frac{\text{score of posttest (\%)} - \text{score of pretest (\%)}}{\text{maximum score} - \text{score of pretest (\%)}} \quad (2)$$

3. Result and Discussions

3.1 Result

3.1.1 Module Effectiveness on Student Critical Thinking Skills

Based on syntax guided discovery learning model and critical thinking skills [16], this study assessed 10 CTS indicators. These CTS indicators, namely (1) formulate hypotheses, (2) record observations, (3) define terms and consider a thing, (4) report experimental results correctly, (5) provide simple explanations, (6) make definitions, (7) write down arguments (ability to give reasons), (8) prove hypotheses, (9) provide further explanations, and (10) write conclusions. The results of CTS analysis for the 11th grade students of SMAN 12 Padang can be seen in Table 1.

Table 1. Results of Student CTS Analysis of Padang 12 State High School,

No	Critical Thinking Skills Indicators	% Critical Thinking Skills/ Meeting					Average	Category
		1	2	3	4	5		
1	Explain the hypothesis	90.94	92.50	83.44	94.69	85.00	89.31	Very good
2	Collect anytime of information	96.56	90.94	85.63	90.00	79.06	88.44	Very good
3	Reported the correct experiment results	96.88	89.06	83.44	91.88	75.56	87.56	Very good
4	provide a simple explanation	88.13	86.56	79.38	94.69	80.63	85.88	Very good
5	Mention the example	87.50	88.44	80.31	94.69	80.94	86.38	Very good
6	Create the definition	87.50	92.19	78.75	94.38	83.13	87.19	Very good
7	Propose argument	87.50	92.19	82.19	94.38	85.31	88.31	Very good
8	Explain conclusion and hypothesis	94.69	93.13	76.56	94.69	80.31	87.88	Very good
9	Identify conclusions	95.94	91.56	79.06	94.69	82.81	88.81	Very good
10	Make a Conclusion	94.06	93.13	78.75	94.69	87.19	89.56	Very good
	Average	91.97	90.97	80.75	93.88	82.09	87.93	Very good
	Category	Very good	Very good	good	Very good	Very good	Very good	

3.1.2 Module Effectiveness on Increasing Student Learning Outcomes

Effectiveness of modules on improving student learning outcomes is obtained from students' N-Gain scores as in Table 2. The difference in the average value of the experimental class N-Gain (0.80) is higher than the control class N-Gain average (0.63). To prove whether the acquisition of N-Gain scores differed significantly or not, a statistical test was carried out with the help of Statistical Package for Social Science Software (SPSS) version 25. Before testing the hypothesis, the normality of the data distribution and the homogeneity of the data variance were tested. Tests for normality and homogeneity of the data were carried out using the Shapiro-Wilk test.

Table 2. Learning Outcomes Data for Grade XI Students of SMAN 12 Padang

Samples	N	Average Value			Category
		Pre-test	Post-test	N-Gain	
Experiment Class	32	37.38	85.38	0.80	High
Control Class	35	46.97	79.89	0.63	Medium

Results Test for normality of sample classes can be seen in Table 3. Data obtained shows that the learning outcomes of the two sample classes are normally distributed; therefore, the homogeneous test is continued. The results of homogeneous test can be seen in Table 4.

Table 3. Tests of Normality Class Samples of

Classes		Shapiro-Wilk		Conclusion
		α	Sig.	
N-Gain	Experiment	0.05	.296	Normally distributed
	Control		.274	Normally distributed

Table 4. Tests of Homogeneity Class Samples

Class		α	Sig.	Conclusion
N-Gain	Experiment Control	0.05	0.606	homogeneous

From Tables 3 and 4, it can be seen that both classes of samples are normally distributed and have homogeneous variance; therefore, hypothesis testing is done by t-test. Hypothesis test results shown in Table 5. Criteria for decision-H_0 based on the significant value on the table test of homogeneity of variance. If the significance value> α (0.05), then accept H_0 and reject if the opposite.

Table 5. Hypothesis Test Results with the T-Test

Class		α	Sig.	Conclusion
N-Gain	Experiment Control	0,05	0,001	Process H_0

Based on the value of learning outcomes obtained the value of t_{count} (3.257) > t_{table} (1.67). Table 5 shows that the significance value of the sample class is greater than α (0.005), and it means reject H_0. This data shows that the research hypothesis is accepted at the 0.05 level. An increase in student learning outcomes in the experimental class using acid-based modules based on discovery learning is significantly higher than the control class without using modules.

3.2 Discussions

3.2.1 Analysis of Module Effectiveness on Student Critical Thinking Skills. It can be seen on Table 1 that the use of acid-base modules based on guided recovery learning is effective in increasing CTS students in Public Senior High School 12 Padang, with a very high effectiveness category which is 81% [14]. Data show from the first meeting to the fifth meeting that the average CTS of students is 87.93%. Increases in CTS for students of Public Senior High Schools in Padang city can also be compared to the data reported in previous studies. In 2012 and 2013, the average CTS students of Padang City Senior High School were 35.13% [17] and 38.83% in 2013 [18].

Increasing student CTS was caused by the module that has been prepared based on the guided discovery learning model syntax, which consists of 5 stages. In the first stage (motivation and problem presentation), students were trained to analyse and formulate problems. In the second stage (data collection), students were guided to collect data through various activities, such as reading various sources, observing objects (pictures, tables, or objects that exist in everyday life), or conducting experiments in the laboratory. In the third stage (data processing), students are guided to process data through the questions and statements that were presented on the student activity sheet. At the fourth stage (verification), students prove the truth of the hypothesis that they have written on the activity sheet at the beginning, after the students collect data and analyse the data. In the fifth stage (closure), students wrote or submitted conclusions of the material that had learned at the meeting [9]. All activities carried out by students were in accordance with the CTS indicators put forward by Ennis (1985) [16].

Increased CTS students in learning with modules based on guided discovery learning, proving that CTS can be trained and taught at school. Teaching students with the idea of finding, thinking critically, asking questions, and problem solving skills is one of the main principles of teaching science and technology [8]. This is also in accordance with what was stated by Tawil and Liliasari (2014) [19], that thinking skills can be taught in schools through direct and systematic ways, can be held in all fields of study in schools and can also be held in separate programs.

The same results for other learning materials were reported by several researchers, those were guided discovery can increase CTS students in light reflection material in junior high school [20], chemistry learning in vocational schools [21], and learning mathematics in college ([22].

3.2.2 Module Effectiveness Analysis on Increasing Student Learning Outcomes

Tables 3 to 4 show that the improvement of experimental class learning outcomes is significantly higher than the control class. It means the use of modules were effective in improving student learning outcomes in Public Senior High School 12 Padang. Improvements of student learning outcomes were due to the availability of acid-base modules based on guided discovery learning. This module was prepared based on the syntax of the GDL model, which can guide students to study, both independently and in groups. The use of acid-base modules in chemistry learning has been proven to improve student learning outcomes. Similar results were obtained from several previous studies, namely the use of integrated science modules based on guided discovery learning (GDL) on water pollution material can improve student learning outcomes and critical thinking skills by 85.5% [23]; the use of chemistry learning modules can improve critical thinking skills of 11th grade students of Public Senior High School 1 Surakarta, Public Senior High School 7 Surakarta, and Public Senior High School 8 Surakarta [24]. This data shows that the instructional material that is prepared based on the learning model syntax applied by the teacher is needed in learning activities.

The preparation of instructional materials based on the syntax of guided discovery learning models also helps the teacher in applying the model, so that the teacher can carry out his role as a facilitator and mentor in learning activities**.** This research obtained in line with the results of the study previously showed that guided discovery can improve CTS students, such as in mathematics learning [24] and chemistry [25].

4. Conclusions and Recommendations

Based on the results of research and data analysis, it can be concluded that the use of acid-base modules based on guided discovery learning can improve CTS and learning outcomes and high school students with a very high level of effectiveness (87.93%). Therefore, this module is suitably used by teachers to improve critical thinking skills and improving learning outcomes of high school students.

References

[1] Vaino K, Holbrook J, and Rannikmäe M 2012 *Chemistry Education Research and Practice* **13** 410–419
[2] Yerimadesi, Bayharti, Fitri H, and Wiwit F L 2016 *Journal of Sainstek* **8(1)** 85

[3] Yerimadesi, Ellizar., Fitri H, and Uswatun H. 2017 *Proc. of the 2017 Semirata in the Field of Mathematics and Natural Sciences-PTN-West BKS (Book 3 Chemistry)* 1892-1902.
[4] Yerimadesi, Ananda P, and Ririanti 2017 *Jurnal Eksakta Pendidikan (JEP)* **1(1)** 17
[5] Bayharti, Yerimadesi, and Hafizatul B 2017 *Proseding Semirata 2017 Bidang MIPA BKS-PTN-Barat*, Buku 3 Kimia, 1834
[6] Ellizar E, Hardeli H, Beltris S, and Suharni R 2018 *Proc. The International Conference on Mathematics, Science, Education and Technology (ICOMSET)IOP Conf. Series: Materials Science and Engineering* **335** 012101 doi: 10.1088 / 1757-899X / 335/1/012101
[7] Smitha VP 2012 *Inquiry training model and guided discovery learning for fostering critical thinking and scientific attitude*. First Edition. Publisher Vilavath Publications, Kozhikode.
[8] Balim A G 2009 *Eurasian Journal of Educational Research* **35** 1
[9] Yerimadesi 2018 *Dissertation Postgraduate* of Universitas Negeri Padang
[10] Udo M E 2010 *African Research Review. An International Multi-Disciplinary Journal.* Ethiopia. **4 (4)** 389.
[11] Akinbobola A O and Afolabib F 2010 *Eurasian J. Phys. Chem. Educ*. **2(1)**16.
[12] Yerimadesi, Bayharti, Jannah SM, Lufri, Festiyed, and Kiram Y 2018 *Proc. The International Conference on Mathematics, Science, Education and Technology (ICOMSET). IOP Conf. Series: Materials Science and Engineering* **335** 012097 doi: 10.1088/1757-899X/ 335/1/012097): IOP Publishing
[13] Lufri and Ardi 2017 *Buku ajar metodologi penelitian: penelitian kuanlitatif, penelitian tindakan kelas & penelitian pengembangan*. Padang: UNP Press.
[14] Riduwan. 2015. *Easy Study Learning for Teachers*, Employees and Beginner Researchers. Bandung: Alfabeta
[15] Hake R R 1999 *Analyzing Change / Gain Score*. Dept. of Physics, Indiana University.
[16] Ennis R H 1985 *A logical basis for measuring critical thinking skills. Educational Leadership*, **43(2)** 44-48.
[17] Ellizar J and Djamas D 2012 Analysis of Critical Thinking and Motivation for Grade XI Students of the Public High School of Padang City, UNP.
[18] Djamas D, Zulhendri K, and Murtiani 2013 *Eksakta* **2(14)** 24
[19] Tawil M and Liliasari 2014 *Science skills and implementation in science learning*. Makassar: UNM
[20] Purwanto C E, Sunyoto E N, and Wiyanto 2012 *UPEJ (Unnes Physics Education Journal)* **1 (1)**
[21] Wahyuni T, Tukiran, and Wahono W 2014 *ejournal.unesa.ac.id/article*.
[22] Aksu G and Koruklu N 2015 *Eurasian Journal of Educational Research* **59** 181
[23] Suhartatik 2016 *Journal of Education* **1**
[24] Gama W P, Ashadi, and Nurma Y T 2017 *Prosiding Seminar Nasional Pendidikan Sains* (SNPS) 150
[25] Lasisi N, Alabi T O, ad Salaudeen M B 2016 *American Journal of Innovative Research and Applied Sciences* 3**(2)** 98