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THE EFFECT OF CHEMISTRY LEARNING BASED ON ANALOGY ON HIGHER ORDER THINKING SKILLS OF SENIOR HIGH SCHOOL STUDENTS IN EQUILIBRIUM CONCEPTS

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Abstract:
The objective of the research is to investigate the difference on Higher Order Thinking Skills (HOTS) between the application of the chemistry learning based on analogy and without analogy. The type of the research was used to the quasi-experimental, while the design of research was non-equivalent control group design with posttest only. The sample in this study was students of class XI IPA (Natural Science) which consisted of two groups. The experimental group (34 students) was taught with chemistry learning based on analogy and the control group (32 students) was taught with chemistry learning without analogy. Nine analogies were used in experimental group. The instrument test consisting of 8 essay questions was applied to both groups. The data from both groups was compared with the independent sample t-test. The results of the research show that there is a significance differences between the experimental group and the control group. Students in the experimental group much better in HOTS than the control group. In conclusion, the chemistry learning based on analogy has positive impact on students' HOTS.

Keywords: analogy, higher order thinking skills, equilibrium concepts

1. Introduction

Chemistry is one of the subjects was taught in Indonesian senior high school. Chemistry is the study of composition, material structure and material changes (Ebbing & Gammon, 2007: 2) and one important thing is that this concept is abstract and requires

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abstract reasoning (Johnstone, 2000), which causes students to assume chemistry is a difficult subject (Carter & Brickhouse, 1989). The results of research conducted by Akani (2017) showed that there were several material topics that students find difficult by acid base titration, analysis of qualitative chemical reactions, reaction rates and energy effects, composition non-metals and metals, chemical applications, nuclear chemistry and astronomical chemistry.

In general, in studying chemistry there are three levels that must be mastered, namely the level of macroscopic, microscopic and symbolic (Johnstone, 2000). At the microscopic and symbolic level it is an abstract level because it is not visible (Demircioglu, Demircioglu, & Yadigaroglu, 2013). Macroscopic representation is a chemical representation obtained through real observation of a phenomenon that can be seen and perceived by the five senses or in the form of daily experience. Microscopic representation, which is a chemical representation that explains the structure and processes at the particle (atomic /molecular) level of the macroscopic phenomena observed. Symbolic representations are qualitative and quantitative chemical representations such as chemical formulas, diagrams, reaction equations, stoichiometry and mathematical calculations (Johnstone, 1993). All these concepts must be integrated with each other so that learning objectives can be achieved.

There are several things that can be done by teachers to overcome students' difficulties in understanding chemical material. One way to make it easier for students to understand abstract concepts is an analogy (Newby & Stepich, 1987). Analogy is a comparison between two similar concepts, namely analog concepts and target concepts. Analog concepts are known concepts, while the target concept is a concept that is not yet known or that will be introduced (Glynn, 2008: 114). Through analogy, difficult and abstract concepts will be compared with familiar objects and daily experiences, so that analogies can be understood well by students (Harrison & Coll, 2008: 2).

We can see the importance of analogy-based chemistry learning from several research results that show that the analogy learning process can increase the conceptual understanding of reaction rates (Eskandar, Bayrami, Vahedic, & Ansar, 2013) and students believe that analogy is an important element to make concepts concrete (Didis, 2015). The application of analogies will make abstract concepts can be visualized with something simple but with the same concept, so that the concepts learned can be easily understood.

Higher Order Thinking Skills (HOTS) was defined in three categories, namely (1) higher order thinking skills as a form of transfer, (2) higher order thinking skills as critical thinking skills, and (3) higher order thinking skills as problem solving skills (Brookhart, 2010: 4-8). Higher order thinking refers to the top three of Bloom's cognitive taxonomy, which is analyzing, evaluating and creating (Anderson and Krathwohl, 2015: 43), therefore, in compiling the question of high-level thinking in this study it involved the last three cognitive domains of Bloom's taxonomy.

Questions HOTS category had been applied to the High School Examination, but it was difficult to complain by students (Effendy, 2018). Based on this information, we can know that students find it difficult to solve problems with the HOTS category, so that from this problem the government and teachers need to improve the learning process by directing students to practice HOTS. The importance of HOTS is motivated by the high competitiveness of international disciplines, which requires the ability of students to be able to solve various problems by looking at various considerations and relationships between one concept and another concept. These thinking skills need to be trained continuously so that they will open the horizons of students' thinking to be more creative, critical and have more advanced thinking power. One of the means to practice HOTS is to apply an analogy based learning system.

Analogy has been widely used to support the success of the learning process, such as to study energy bonds (Shahani and Jenkinson, 2016), alkane nomenclature (Orvis, et al., 2016), quantum theory (Didis, 2015), and chemical equilibrium (Naseriazar, Ozmen, and Badrian, 2011). One of the chemical materials taught at the high school level is chemical equilibrium. Chemical equilibrium is the condition when the rate of the forward reaction and the reaction back are equal and the concentration of reactants and products no longer changes over time, chemical equilibrium is achieved (Ebbing & Gammon, 2007: 582).

Ozmen (2008) in his research showed that the results of tests using the Test Identify Students' Alternative Conceptions (TISAC) contained four chemical equilibrium sub-material containing misconceptions, including Le Chatelier's principles, equilibrium constants, heterogeneous of equilibrium and catalyst effects. The same thing is also stated from the results of Demircioglu, Demircioglu, and Yadigaroglu (2013) found that chemical equilibrium contains difficult concepts; this is indicated by the existence of misconceptions at several levels of the class. Misunderstanding was related to changes in equilibrium conditions (temperature, concentration, catalyst effect, Le Chatelier's principle and equilibrium characteristics) with a percentage range of misunderstandings from 23.7% to 46.3%.

Based on the explanation the aimed of this study investigate the difference on Higher Order Thinking Skills (HOTS) between the application of the chemistry learning based on analogy and without analogy. Within this aim, the following research questions were explored: 1. is there significant difference on Higher Order Thinking Skills (HOTS) between the application of the chemistry learning based on analogy and without analogy? 2. if there is significant difference, which groups much better in Higher Order Thinking Skills (HOTS)?

2. Literature Review

2.1 Analogy

Analogy (derived from Greek "analogia") which means the relationship of conformity, similarity between things, both in physical, intellectual or moral order. Etymologically, analogy means parallel reading. When applied to the domain of science learning, this definition refers to the parallel with the relationship of similarity between certain scientific concepts to be conveyed with something tangible, simple, and already existing in the mindset of students (Paiva & Gil, 2008)

Analogy is a comparison between two similar concepts, namely analog concepts and target concepts. Analog concepts are known concepts, while the target concept is a concept that is not yet known or that will be introduced. Between these two concepts must support each other. A good analogy is when analogous concepts can explain the concept of target, simple, easy to remember and familiar (Orgill & Bodner, 2004) so that analogy can be said as a form of raising a concept with a concept that has been understood by students. So that there are two different things aligned, but have similar concepts or principles. One concept that will be understood will be supported by the understanding of other concepts that have been understood by previous students.

The use of analogies in teaching science can sometimes be an obstacle to scientific knowledge if one uses it (Paiva & Gil, 2008). So that the application of analogies can be applied properly, there needs to be systematic steps. There are several systematic applications of analogies, one of which is the FAR guide, as used in this study.

The Focus stage is the stage where the teacher ensures the learners know the educator's arguments using an analogy, at the stage of the Action the teacher ensures that the students recognize the objects or daily experiences that they want to use as analogs. Education must always discuss the parts of analog that can be used (similar traits) and cannot be used (different traits), while in the Reflection stage the teacher evaluates the effectiveness of the use of analogies, and asks himself about the need to revise the explanation and look for other ways better at using the analogy later (Harrison & Coll, 2008: 2). This can be seen in Table 1.

Table 1: Application of Analogy with FAR guide

Focus	
Concept	Is it difficult, foreign or abstract?
Student	What do students know about the concept?
Analog	Have students known the analog?
Action	
Similar	Discuss analog traits and science concepts
Not similar	Also discuss when analogues do not resemble scientific concepts
Reflection	
Conclusion	Is this analogy clear, useful or confusing? Do the results as planned?

2.2 Higher Order Thinking Skills (HOTS)

Higher Order Thinking Skills (HOTS) is an important aspect in the learning process, which allows students to access, manage, interpret and apply knowledge (Balisteri, Giacomo, Noisetta, & Ptak, 2012: 13). The practice of thinking skills is part of general abilities that must be included in all subjects. Students with high-level thinking skills will improve performance and reduce their weaknesses (Heong et al., 2011). Operationally the HOTS used the highest cognitive domain in the Bloom taxonomy (Brookhart, 2010: 5), namely at the level of analyzing (C4), evaluating (C5) and creating (C6).

The cognitive domain of C4, the emphasis is on decomposing the material into its constituent parts and detecting the relationships of those parts and the way they are organized and linked (McGregor, 2007: 17). Analyzing includes the cognitive process of differentiating, organizing, and attributing (Anderson & Krathwohl, 2001: 79). C5 cognitive domains require students to conduct assessments for several goals, ideas, works, solutions, methods, materials, and so on. Involves the use of quantitative or qualitative criteria and standards (McGregor, 2007: 17). Evaluating categories include cognitive processes checking and critiquing (Anderson & Krathwohl, 2001: 83). The C6 cognitive domain requires students to combine several parts to form new parts so that they become new products. Creating categories include cognitive processes generating, planning, and producing (Anderson & Krathowohl, 2001: 84)

3. Material and Methods

3.1 Research Design

The method in this study was quasi experimental. The research design was nonequivalent control group design research with posttest only. The study was conducted on State Senior High School of IPA (Natural Sciences) class XI consisting of two groups: experiment and control groups. The experimental group applied the learning chemistry strategy based on analogy, while the control group applied the chemistry learning without analogy. The learning activities can be seen in Table 2.

Table 2: The Learning Activities in Experimental and Control Groups

Learning Activities	Experimental Group	Control Group
Observe	• Students observe images of phenomena or events in the LKS • Students observe the images on the LKS and understand the relationship between concepts analogous to the target concept	• Students observe images of phenomena or events in the LKS
Ask	• Students make questions based on observations that have been made	• Students make questions based on observations that have been made
Gathering Information	• Students complete several questions in the LKS • Students make analogy	• Students complete several questions in the LKS
Associate	• Representatives from each group provided an explanation of the answers and information they obtained regarding chemical equilibrium • Students pay attention and listen to the explanation of the analogy from the teacher.	• Representatives from each group provided an explanation of the answers and information they obtained regarding chemical equilibrium • Students pay attention and listen to the teacher's explanation
Communicate	• Some students concluded about chemical equilibrium material and other students watched and listened carefully	• Some students concluded about chemical equilibrium material and other students watched and listened carefully

3.2 Participants

The total sample used in this study was 66 students who came from two groups. The experimental group consisted of 34 students and the control group consisted of 32 students. This study was undertaken at one of the senior high schools in Yogyakarta (Indonesia) from October to November 2018.

3.3 Instrument

Instrument to measure student's HOTS used posttest result data on chemical equilibrium in the form of essay containing Bloom's cognitive level from C4 to C6. Chemical content, indicator of competency, type of representation and cognitive level of the instrument are shown in Table 3.

The instrument validated by content validity and empirical validity. The content validity of HOTS test will be further analyzed by using the Aiken'v index, so that in addition to being conducted by two expert lecturers, it was also conducted by 6 other validators consisting of five peers and one practitioner. The validators were asked to assess the validity of the item. Assessment is carried out in the following format: 1 = invalid; 2 = less valid; 3 = enough; 4 = valid; 5 = very valid.

After evaluated, the assessment results are combined in one table and calculated by the Aiken 'V index of expert agreement for each item.

The Aiken formula used is as follows (Aiken, 1985).

$$V = \Sigma s / [n (c-1] \quad (1)$$

Note: V = validity; s = r – lo; r = number given by raters; Io = minimum validity score; c = maximum validity score

Table 3: Blueprint of HOTS Test

Content	**Indicators of Content**	**Indicators of HOTS**								**Number of Question**
		C4			**C5**		**C6**			
		a*	**b***	**c***	**d***	**e***	**f***	**g***	**h***	
Dynamic Equilibrium	Explain dynamic equilibrium	1, 2				3				3
Constant Law and Equity	Processing data to determine equilibrium constant values (K_C and K_P)	6, 7, 8			4, 5, 9, 10					7
	Analyze data to determine the relationship of equilibrium constant values	12	11							2
	Analyze data in the calculation of a dissociation equilibrium system	13, 14,								2
Factors that affect Chemical Equilibrium	Determine the shift in chemical equilibrium based on changes in concentration, pressure, volume and temperature	19			15, 17, 18, 22	20	16, 21			8

Note: a). Differentiating, b). Organizing, c). Attributing, d). Checking, e). Critiquing, f). Generating, g). Planning, h). Producing

The value of V obtained compared with the value of the coefficient of validity. Based on the table of validity coefficients with a significance value of 5%, each item will be declared valid if the value of the validity of the item is greater than 0.75. The results of the analysis using the Aiken formula from 22 items in the description show that all items have a validity coefficient> 0.75, so it is declared valid.

After revision, the instrument validated with empirical validity. Instrument consisting 22 questions was piloted to 144 students whom the outside the study sample. In this study empirical validation was done using the Rasch model with Winstep software. According Boone, Staver, & Yale (2014), the criteria of validity are MNSQ Outfit: 0.5 <MNSQ <1.5; ZSTD Outfit received: -2.0 <ZSTD <+2.0; Pt Mean Corr: 0.4 <Pt Measure Corr <0.85. Based on the the criteria, items number 2, 6, 8, 9, 15, and 22 misfit.

The Rasch model provides an index that helps researchers determine whether items are sufficiently spread along the continuum. The item reliability index will show the placement of items along the path, if the same items given to different samples will produce the same results (Bond & Fox, 2007: 40-41). Reliability test in this study was analyzed using the Rasch model by taking into account the value of alpha Cronbach, person reliability, and item reliability. The value of alpha Cronbach is 0.81. Based on criteria for interpreting the results of the Cronbach alpha reliability test is good criteria. While the value of person reliability is 0.64 and the value of item reliability is 0.99. According to Fischer (2007) criteria, the results of the analysis of the reliability of person is weak, but the items in the instrument is special reliability.

Based on the Rasch assumption test, validity criteria, and reliability, the questions used as instruments for measuring HOTS in this study consisted of 8 questions that were fit with the model, representing each indicator of the problem, and representing the cognitive domain of HOTS. The 8 questions can be seen in Table 4 below:

Table 4: Valid Question Numbers and Research Instrument Questions

Valid Question Number	Research Instrument Question Number
1, 3, 4, 5, 7, 10, 11, 12, 13, 14, 16, 17, 18, 19, 20, and 21	1, 5, 10, 12, 13, 16, 19, and 21

Students' HOTS were analyzed from the results of the description tests covering the cognitive domains C4 to C6. The number of questions given is 8 questions that represent eight question indicators, and each question indicator consists of one question. The question number and its cognitive domain can be seen in Table 5:

Table 5: Question Number and its Cognitive Domain

Question Number	Cognitive Domain
1	C4
2	C5
3	C5
4	C4
5	C4
6	C6
7	C4
8	C6

4. Results and Discussion

The HOTS of students between the experimental group and the control group were analyzed by conducting the t-test, but before the t-test was conducted, there are 2 assumptions that must be fulfilled, namely the data must be homogeneous and normally distributed. In this study the homogeneity test was carried out using the Levene test (Vorapongsathorn, Taejaroenkul, & Viwatwongkasem, 2004). The Data will be homogeneous if the significance value is greater than 0.05. The results of the analysis obtained a significance value of 0.0651 > 0.05, so that the data was declared homogeneous.

The technique used for the normality test in this study is to consider the sig value. Kolmogorov and sig. Shapiro-Wilk which is a normality test that has strength for all types of distribution and sample size (Razali & Wah, 2011). The Data will be normally distributed if the significance value is greater than 0.05. The results of the Kolmogorov analysis obtained a significance value of 0.1506 > 0.05 and the results of the Shapiro-Wilk analysis obtained a significance value of 0.063 > 0.05, so that the results of the two data analyzes were declared to be normally distributed.

Homogeneous assumptions and normality in this study have been fulfilled, so that the t-test can be continued. The t-test analysis refers to the statistic hypothesis as follows:

H_0: There is no significant difference on HOTS between the application of the chemistry learning based on analogy and without analogy.

Ha: There is a significant difference on HOTS between the application of the chemistry learning based on analogy and without analogy

The decision-making criteria for the results of the analysis are if the significance value is ≤ 0.05 then the null hypothesis is rejected (Pallant, 2007: 235). The significance value (2-tailed) obtained is 0.00, so that in this case the null hypothesis is rejected. The conclusion of the results of the t-test is that there are differences in the HOTS of students between the experimental group and the control group.

This study applies the use of analogies to study chemical equilibrium material. Naseriazar, Ozmen, and Badrian (2011) said that the use of analogies in order to teach chemical equilibrium material has been discussed for years. In this study there are several analogies used to teach chemical equilibrium taken from everyday events that have forms or processes that are relevant to the material to be studied. The learning process in chemical equilibrium material takes 4 times, both in the experimental and control groups. After the learning process is over, in the fifth time students are given an evaluation task to find out and analyze their HOTS. Analysis activities are carried out by paying attention to students' skills in each cognitive domain (C4, C5, and C6).

Based on the results of post-test, the average value of students in the experimental group is higher than the control group. The results of the t-test analysis showed that there are significant differences between the two groups, so the analogy-based chemistry learning in this study has a positive effect on students' HOTS. There have been many previous studies explaining that the teaching of analogies can improve understanding of scientific concepts that support the results of this study (Naseriazan, Ozmen & Badrian, 2011; Suparson & Promarak, 2015; Eskandar, Bayrami, Orgil, Bussey and Bodner, 2014).

A similar study conducted by Naseriazar, Ozmen, and Badrian (2011) stated that the test results showed that the average score of the experimental group was higher than the control group and there were significant differences between the two groups. Based on the results of the study, it was suggested that analogies can help students visualize abstract concepts, compile their thoughts about the topics given, and study the topic as a whole. Orgill and Bodner (2004) in their study state that in biochemical subjects, analogies help students to learn and remember biochemical material.

The analogy implementation carried out by Suparson and Promarak (2015) also showed the same thing. The majority of students (more than 50%) understanding students in several categories of material the reaction rate is included in the good category. This study also verifies that the implementation of inquiry supported by analogy learning activities is an effective means of improving and retaining students' conceptual about the rate of chemical reactions. Orgil, Bussey and Bodner (2014) explain that from the research conducted there are several reasons for choosing an analogy, 1) helping students learn difficult concepts into easy concepts; 2) help students connect what they understand to the concepts they have learned; 3) help students visualize abstract concepts; 4) involving and attracting students' attention; 5) provide a framework for understanding several phenomena.

In this study the beginning of learning activities, students are introduced to the material to be studied, the definition of the analogy and the purpose of using the analogy. Ensuring students recognize the analogy to be used is a very important thing to do, because according to Orgil, Bussey and Bodner (2014) one of the causes of learning failure using analogy is that students do not recognize the analogy used so the chemical concepts to be conveyed are also not understood well by students. During the learning process besides the teacher introducing the analogy used, students are also trained to found for different analogies to explain the material being studied, with the hope that if the analogy is found to be the same as the concept of chemical equilibrium the students will understand the material that has been learned. The concept of evaluation used is that students are asked to explain aspects that are similar and which are not similar between the concepts of analogy and the concept of chemical equilibrium, so from a learning system that will train students' thinking skills to be able to analyze, evaluate, and create events in the surrounding environment that are relevant to the concept of chemical equilibrium. This will make it easy for students to be able to solve problems that require high level thinking. In addition to the perceived benefits of students, the use of analogies is also felt to be beneficial for pre service teacher, like study done by Mustu and Ozkan (2017) said that analogy is important to help pre service teachers to understand abstract concepts.

6. Conclusion

The objective of the research is to investigate the difference on Higher Order Thinking Skills (HOTS) between the application of the chemistry learning based on analogy and without analogy. The result showed that chemistry learning based on analogy has a significant difference on Higher Order Thinking Skills (HOTS). Students in the experimental group ($\bar{x} = 70{,}86$) much better in HOTS than the control group ($\bar{x} = 50, 72$).

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