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EFFECTIVENESS OF INQUIRY-BASED LEARNING TOWARDS MASTERING THE CONCEPT OF UNSATURATED HYDROCARBONS IN UNDERGRADUATE STUDENTS

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ABSTRACT

Inquiry learning can be applied to chemistry learning at any level of education. This is according to the characteristics of chemistry, which is based on empirical evidence for real-world study. One of the topics studied in Organic Chemistry Lecture is an unsaturated hydrocarbon that discussed the structure, nomenclature, properties, manufacture, and usability. There are various models or strategies of inquiry for chemistry learning, especially guided inquiry. One of the guided inquiry-based chemistry learning strategy innovations is the OE_3R (Orientation - Exploration - Explanation - Elaboration - Reflection) strategy for various education levels, high schools, and universities. This research aimed to determine the effectiveness of guided inquiry-based learning with OE_3R strategy in undergraduate students' conceptual understanding of the Unsaturated Hydrocarbon concept. The research using a Quasi Experiment with a pretest-posttest control group design. Conceptual understanding with OE_3R Strategy proven to be better than Expository Strategy. This can be seen from achieving minimum completeness criteria, which is 92.3% for OE_3R and 72.2% for expository. It can also be seen from the N-gain value for the OE_3R Strategy (0.43), which is significantly better than the Expository Strategy (0.27).

Keywords: conceptual understanding, inquiry-based learning, OE_3R strategy, unsaturated hydrocarbon

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1. INTRODUCTION

Chemistry is a science that focuses on nature, reactions changes, and its energy that accompanies compositions and structures. Based on these characteristics, chemistry has various concepts: abstract concepts, concrete concepts, and defined concepts. Organic Chemistry studies at the university level discuss several topics. One of them is unsaturated hydrocarbons. Unsaturated hydrocarbon topics are alkenes, alkynes, and benzenes, focusing on structures, nomenclatures, natures, manufacture, and usefulness. This topic has all three characteristics of the concept. To understand the concept well, the three characteristics of the concept must be combined in its entirety.

A comprehensive understanding of the chemistry learning process concepts involves three levels of representation: macroscopic, submicroscopic, and symbolic (Talanquer et al., 2011). Macroscopic representation is a chemical representation through real observation of a phenomenon that can be sensed. Submicroscopic representation is a chemical representation that explains a reviewed phenomenon from the molecular level. Symbolic representation is a chemical representation toward converting a substance into chemical formulas, reaction equality, or charts.

Understanding the concept of chemistry can be seen based on students' ability to connect and transfer these three-representations into different situations. For instance, in one of petroleum, it is solar. In macroscopic representations, it is understood that solar is liquid and flammable. Sub-microscopic representations are in the perfect combustion diesel process, i.e., solar reactions with oxygen that produces carbon dioxide and moisture. This level involves the concept of reasoning the disconnection of hydrocarbon chains in a diesel by oxygen molecules and establishing new compounds of carbon dioxide gas and water vapor. Symbolic representations can be written in reaction equations, there is $2C_{12}H_{26}(l) + 37O_2(g) \rightarrow 24CO_2 (g) + 26H_2O(l)$.

In order to be able to understand the macroscopic, sub-microscopy, and symbolic representations fully, strategic movement is needed. This movement can be seen as six domains of science, namely concepts, processes, applications, attitudes, creativity, and the nature of science (Enger et al., 2009). The role of the science domain contains elements of exploring and investigating how scientists work and think. Thus from this domain, it is assumed that knowledge is found and obtained, so the science process is frequently designed as inquiry skills.

Inquiry learning is an observed based learning process that invites students' to carry out scientific processes as scientist study nature, allowing them to use all their competencies to discover the concept itself (Nugraha et al., 2016; Panasan et al., 2012). Inquiry teaches skills such as problem-solving, critical thinking, integrating science process skills, learning through groups cooperatively, using high-level thinking skills, manipulating and measuring skills, using mathematical operation, and communicating (Iskandar, 2015).

Based on those skills that can be trained above, students' are required to be active in learning. In accordance with the characteristics of the science learning process, there are (1) engage in scientific questions; (2) prioritize evidence; (3) formulate explanations based on evidence; (4) evaluate the explanation in accordance with scientific concepts; and (5) communicate and justify claims of knowledge (NRC, 2000). In learning, the teacher acts as a facilitator during the learning process to ask about concepts or problems related to the learning material. In addition, teachers should be able to create a conducive environment for learning.

This learning model invites students' to understand science through scientific methods aiming to understand the concept that is informative and involves student activities in building an understanding of concepts (Magfirah et al., 2019). Chemistry learning involves students' activities and skills to understand better the knowledge students' want to know (Haury, 2015). Inquiry-based learning has to involve each learner in his/her meaningful, appropriate, and truth-based learning activities so that learners will understand the true nature of science as a process, product, and attitude (Masruroh et al., 2019). Inquiry learning activities focus on the essential concepts and processes to encourage and foster a deep understanding of the material (Alhudaya et al., 2018).

There are various models of guided chemical learning strategies, including (1) Process Oriented Guided Inquiry Learning (POGIL) (Hanson et al., 2006); (2) The Model Observe Reflect Explain (MORE) Thinking Frame (Mattox et al., 2006); (3) Five Stages according to Wenning: Observation–Manipulation–Generalization–Verification-Application (Wenning, 2005); (4) Five Stages according to Pedaste, i.e., Orientation–Conceptualization–Investigation–Conclusive-Discussion (Manoli et al., 2015); and (5) OE_3R Strategy (Sutrisno, 2018).

Based on several studies, it shows that guided inquiry learning can improve conceptual understanding and learning achievements in chemistry (Lin et al., 2016), improve mastery of concepts and attitudes towards science (Zeidan et al., 2015), provide significant results on the achievement of mastery of learning concepts (Supasorn et al., 2014), and improve students' learning understanding of chemistry, skills, and attitudes attitudes (Sesen et al., 2013).

The inquiry-based learning strategy implemented in this research is executed based on three representation and six science domains, namely the OE_3R Strategy. The OE_3R strategy stands for the initial letter of each stage, namely Orientation-Exploration-Explanation-Elaboration-Reflection.

The learning stages with the OE_3R Strategy in terminology are easy to understand and reflect the learning activities carried out to be convenient to implement. The purpose of this study is to find out the effectiveness of inquiry-based learning guided by the OE_3R Strategy towards mastering student concepts on the unsaturated hydrocarbons topic.

2. RESEARCH METHOD

The design of this study uses Quasi Experiment with pre-test post-test control group design research model. This research was conducted on students' of the bachelor - Chemistry Study Program, Department of Chemistry, FMIPA of Universitas Negeri Malang in September - October 2019. The samples were taken using convenience sampling techniques. This study has two groups, namely the learning experiment group using the OE_3R Strategy and the control group with the Expository Strategy. The research model can be seen in Table 1.

Table 1. Pre-test Post-test Only Control Group Design

Groups	Pre-test	Treatments	Post-test
Experiment	O_1	X_1	O_1
Control	O_1	X_2	O_1

Descriptions:
- X_I: Learning Process with OE_3R Strategy
- X_2: Learning Process with Expository Strategy
- O_1: Early Test before treatment and test after treatment in OE_3R Strategy and Expository Strategy

This research uses two types of instruments; there are treatment instruments and measurement instruments. Treatment instruments consist of RPPS (Semester Learning Implementation Plan) and MFI (Student Worksheet). Meanwhile, measurement instruments include a concept mastery test instrument that amounts to 45 items of selected-response type test with multiple-choice, reasoned multiple-choice, and completely reasonable. Before use, the instrument was tested for the validity of its contents by two chemistry lecturers of FMIPA UM. The validity of the assessment instrument's contents is 88.52, which indicates that the assessment instrument has excellent validity.

The data was gained from pre-test and post-test results in the experimental group and control group. To find out the difference in students' mastery concept hypothesis test was conducted using a t-test. However, the first performed prerequisite test analysis is a normality test and homogeneity test. The improvement of student concept mastery in both groups is determined using the analysis of the N-gain score.

3. RESULT AND DISCUSSION

The data used to determine the difference in students' mastery concepts was obtained from post-test scores on unsaturated hydrocarbons topics (alkenes, alkynes, and benzene). The detailed scoring result of students' mastering concepts in both groups can be found in Table 2.

Table 2. The Scoring Result of Students' Mastery Concepts on Unsaturated Hydrocarbon Topic

Groups	Averages	Students' with a score above the pass minimum value (≥55)	Maximum Score	Minimum Score	S_D
Experiment	67.54	24	83	53	8.48
Control	57.33	13	72	33	9.57

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Before the hypothesis test, the analysis's prerequisite test is carried out in advance, namely the homogeneity test and normality test. The test results of homogeneity and normality can be seen in Table 3. In addition, two average similarity tests were also conducted, presented in Table 4.

Table 3. The Result of Homogeny and Normality Tests in Students' Mastery Concepts

Groups	Significance Score	
	Normality Test	Homogeny Test
Experiment	0.872	0.994
Control	0.756	

Table 4. The Result of Experimental Similarity between Two Averages of Students' Mastery Concepts

Groups	Significance Score	Conclusion
Experiment	0.535	The *pre-test* data of mastering concepts is not different in the two groups.
Control		

Normality test results obtained the significance value of both groups greater than 0.05. The value indicates that the data distribution of the experimental group as well as the control group, is normal. Homogeneity test results obtained the significance value of both groups greater than 0.05. The value indicates that the experimental group's data distribution and the control group has a homogeneous variant.

The similarity test of the two average students' mastery concepts is used to find out whether the pre-test scores of the two groups are different or not. The similarity test results of two average students' mastery concepts obtained a significance value greater than 0.05. The value indicates that there is no difference in concept mastery pre-test data.

Differences in conceptual mastery are determined by parametric statistical analysis (t-test) with a significance of 0.05. Hypothetical test results are presented in Table 5.

Table 5. The Data Result of *t-test* in Mastery Concepts

Variables	Score t_{count}	Score t_{table}
Mastering Concepts	3.725	1.682

Based on the results of the t-test above shows that the research hypothesis is accepted. Thus, there are differences in students' mastery concepts with OE_3R Strategy and Expository Strategy. In addition, the difference was shown from the average score with a superior OE_3R Strategy (67.54) compared to the Expository Strategy (57.33), and the number of students' who scored above the minimum pass score for the OE_3R Strategy was 92.31%. In comparison, the Expository Strategy was 72.22%. These results are in accordance with Imas et al. research that the OE_3R Strategy has a good impact on mastery of the concept of learning (Imas et al., 2020).

The data used to determine the improvement of students' mastery concept was obtained from pre-test and post-test values on the unsaturated hydrocarbons topic (alkenes, alkynes, and benzene). The improvement of students' mastery concept is determined using N-gain score analysis. N-gain score test result data can be seen in Table 6.

Table 6. The Data Result of *N-gain score* in Students' Mastery Concepts

Groups	Pre-Test Averages	Post-Test Average	Gain Score	Characteristics
Experiment	41.42	67.54	0.43	Middle
Control	41	57.33	0.27	Low

Based on the analysis results, it is obtained an average value of N-gain with the OE_3R Strategy of 0.43 while the Expository Strategy of 0.27. The analysis of average N-gain values showed that the increase in mastery of student concepts with the OE_3R Strategy falls into the medium category. In the Expository Strategy, the improvement of students' mastery concept belongs to the low category. These results are in line with Sutrisno et al., who says that the

OE_3R Strategy is superior in improving learning mastery concepts to Conventional Strategies (Sutrisno et al., 2018). Inquiry-based learning emphasizes the learning process using the scientific steps in the science process skills so that the mastery concept can be well-formed (Kurniawati et al., 2016).

The application of learning strategies with certain syntax/stages requires students' to actively conduct the learning process to impact the formation of the concept of material so that the mastery of the student concept will be better when there are certain learning strategies. At the students' training orientation stage, it is aimed students' to associate new information received with relevant concepts that have been contained in their cognitive structure to stimulate students' curiosity towards the concept. Exploration phase, making students' active to collect data, facts, the information in their cognitive structure. This causes an imbalance in the processing of information so that students' try to interpret the data that has been obtained into new knowledge for them. At the explanation stage, students' develop and analyze concepts based on facts, data, information obtained from the exploration stage so that a conclusion is obtained to the concept studied (Rahmawati et al., 2018). The activity will provide meaningful learning and help students' to understand the concept as a whole (Widarti et al., 2018).

The OE_3R strategy is one of the inquiry-based learning strategies. Inquiry-based learning can train students' to observe, collect, analyze, synthesize, and make conclusions. It has the impact to develop problem-solving skills and make learning more meaningful (Andrini, 2016; Glackin et al., 2017; Villagonzalo, 2014). The exploration and discovery phase of concepts in inquiry-based learning helps students' find relevant information from various sources. It directs them to find concept patterns based on the results of the information obtained to help develop concept mastery (Hanson et al., 2006). These steps in inquiry-based learning can encourage learners to improve their thinking skills (Sulistyowati et al., 2020). The application of inquiry-based learning also makes learners get a concrete learning experience by interacting and observing objects directly, so learning becomes more interesting (Khanifah et al., 2012).

The OE_3R strategy was developed based on hybridization in three levels of representation and six domains of science. Three levels of representation (macroscopic, sub-microscopy, and symbolic) can connect students' understanding of chemical concepts, then the interconnection of the three representations can help improve students' conceptual understanding. Based on six science domains, concepts are central to science, and students' understanding is essential to success in learning. In science learning, especially chemistry, physical activity is required in lab-based or non-lab investigation processes to understand concepts (Sutrisno et al., 2020). The result of the investigation process can be constructed into a whole concept. At the elaboration stage, training the concepts that have been obtained to be applied to new problems in the same context. Besides that, the concept's application is verification of students' attitudes toward the learning process. In addition, students' have also had creativity and the nature of science to apply the concept overall. This is where the implications of the stage of reflection. Several studies have also shown that inquiry-based learning has a positive influence on improving the mastery of learning science process concepts and skills (Alhudaya et al., 2018; Ambarsari et al., 2013; Simsek et al., 2010), having a good impact on higher-order thinking skills (HOTS) and LOTS (lower-order thinking skills) of learners (Izzatin et al., 2018; Putri et al., 2018; Sutrisno, et al., 2020), and improving understanding of science and academic achievement (Azizmalayeri et al., 2012; Chan et al., 2012; Margunayasa et al., 2019).

4. CONCLUSION

Inquiry-based learning with the OE_3R Strategy effectively implements students' mastery concept on unsaturated hydrocarbons topics (alkenes, alkynes, and benzene). The number of students' who scored above the minimum graduation rate with the OE_3R Strategy was 92.3%, while in the Expository Strategy, it was 72.2%. Similarly, there was an increase in concept mastery with an N-gain of 0.43 in the OE_3R Strategy and 0.27 in the Expository Strategy. Based on this study's results, the OE_3R Strategy is recommended as one of the inquiry-based learning strategies for the same learning topics or other topics, both in high school and college.

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