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Inquiry Based Learning with OE3R Strategy and Its Impact on Students' Mastery of Basic Concepts of Analytical Chemistry

Pradita Rahmadhani, Sutrisno, Hayuni Retno Widarti
Chemistry Education-Universitas Negeri Malang
Jl. Semarang 5 Malang-65145, East Java, Indonesia. E-mail: praditaaa22@gmail.com

Abstract: The purpose of implementation of OE_3R Strategy on lecturing Fundamental of Analytical Chemistry are to determine differences of students' conceptual understanding achievements. This researchidesigniusingiaiQuasi-experimental (one group pre-test-post-test) with different treatment for both groups. The Experimental Group learn using OE_3R Strategy, then the Control Group using conventional strategy. The subject of research was student in Fundamental of Analytical Chemsitry courses in Chemistry Department StateiUniversity of Malang. The result show that inquiry-based learning with OE_3R Strategy as innovation learning effective to make differences of students' conceptual understanding achievements on Fundamental of Analytical Chemistry courses.

Key Words: inquiry based learning; OE3R strategy; conceptual mastery

Abstrak: Implementasi strategi OE_3R pada matakuliah Dasar-dasar Kimia Analitik bertujuan untuk mengetahui perbedaan hasil penguasaan konsep mahasiswa. Desain penelitian ini menggunakan *quasy-experimental (one group pretest-posttest)* dengan perlakuan berbeda pada kedua kelompok. Pada kelompok eksperimen dibelajarkan dengan strategi OE_3R, sedangkan pada kelompok kontrol menggunakan strategi konvensional. Subjek penelitian ini adalah mahasiswa peserta matakuliah Dasar-dasar Kimia Analitik di Jurusan Kimia Universitas Negeri Malang. Hasil penelitian menunjukkan bahwa pembelajaran berbasisis inkuiri dengan strategi OE_3R sebagai sebuah inovasi pembelajaran efektif untuk membuat perbedaan pada hasil penguasaan konsep peserta didik pada matakuliah Dasar-dasar Kimia Analitik.

Kata kunci: pembelajaran berbasis inkuiri; strategi OE_3R; penguasaan konsep

INTRODUCTION

Chemistry is a branch of science concerned with the properties, reactions, and changes of mat ter, as well as the energy associated with these changes, composition, and structure. According to Middlecamp and Kean (1985), mastery of concepts in chemistry encompasses not only knowledge (facts, concepts, and theories), but also science-chemistry as a process and essence of science. These characteristics are embodied in six domains of science, particularly regarding concepts, processes, applications, attitudes, creativity, and the nature of science (Nature of Science) (Enger & Yager, 2009). Meanwhile, the characteristics of chemistry refer to three distinct levels of representation, notably macroscopic, (sub) microscopic, and symbolic (Talanquer, 2011). Fundamentals of Analytical Chemistry is one of the chemistry subjects (courses) taught at the university level. According to Samara (2016), analytical chemistry is a subject that requires mastery of a large number of concepts and contributes significantly to the development of understanding in other branches of chemistry. Analytical chemistry is a field of study in chemistry that presents numerous difficulties in terms of the authentic development of a concept (Hanson, 2017).

The West African Examinations Council (WAEC) investigates five factors that contribute to the low level of chemistry learning in general. One of these weaknesses is an inability to respond coherently and conceptually to questions about chemistry. According to Hanson (2014)'s research in Ghana, students are unable to make connections between the three levels of representation, thereby establishing a false and insuf-

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ficient foundation for further chemistry studies, particularly in analytical chemistry. This is consistent with Arsyad's (2011) assertion that a lack of representation in learning is one of the factors contributing to low/weak student concept mastery. According to Haryani et al. (2007), there are several weaknesses among students enrolled in the Analytical Chemistry course, specifically that students who have completed practical activities are still unable to explain basic concepts related to practicum. Additionally, students demonstrate a decreased ability to explain the symptoms observed during the practicum. Students struggle with analytical chemistry because of ineffective learning methods, low motivation, and student laziness (Uwaleke, 2013). The difficulty encountered thus far in comprehending certain concepts is due to the delivery of material that is not systematic, lecture-based, and rarely incorporates interactive media. This results in a lack of concept mastery, which leads students to memorize concepts.

Based on the issues discussed above, it can be concluded that conceptual mastery is still lacking in analytical chemistry courses. Concept mastery is critical because mastering a concept enables students to more easily grasp both classroom material and its application in daily life. When students learn, they construct knowledge into a complete concept, which is then used as the basis for thinking in order to formulate and solve a problem (Andrianie, 2018). According to Hidayahi (2016), understanding and mastery of prior material or concepts are prerequisites for mastering the subsequent material or concept, such that if the previous prerequisite concept is not understood correctly, understanding the subsequent concept will be difficult. As a result, learning that emphasizes concept mastery as a prerequisite for problem solving is required.

One alternative is to use one of the student-centered science learning strategies to allow students to explore their inherent abilities. Chemical science, according to the American Association for the Advancement of Science (ASSI), places a premium on exploring and investigating activities. This is in accordance with Minister of Research, Technology, and Higher Education Regulation No. 44 of 2015, which states that one of the characteristics of higher education learning is that it is student-centered. Student-centered education means that graduates achieve their goals through the process of developing independence in seeking and discovering knowledge. Investigation activities are obtained through physical (hands-on) and mental (minds-on) activities that assist students in mastering science concepts (Kurniawati, 2014). It is not uncommon for scientific discovery to be obtained and completed through the use of inquiry thinking. Thus, chemistry is acquired through inquiry thinking. There have been several models of inquiry-based learning developed, including (1) the LC (Learning Cycle) 7E (Einskraft, 2003), (2) POGIL, (3) MORE, (4) Wenning's Five Phases (2015), Pedaste et al's Five Stages (2015), and (6) Sutrisno's OE3R learning strategy (2018).

Suparson and Promarak (2014) found that implementing inquiry-based learning results in significant gains in student concept mastery. Additionally, Pahriah (2018) asserts that inquiry-based modules with multiple representations are effective at increasing students' conceptual mastery. Between before and after, the results demonstrated a significant increase. According to Sastrika (2012)'s research, conceptual mastery is a critical factor in determining student learning outcomes.

METHOD

The research design used in this study was a quasi-experimental (one group pretest-posttest) in two groups. The population of this research was third-semester students who took the Fundamentals of Analytical Chemistry course at Faculty of Science and Mathematics, State University of Malang. Sampling in this study was carried out using a convenience sampling technique. Sampling was based on ease of access by researchers where one class as the experimental group was taught with the OE3R strategy and another class as the control group was taught with the conventional strategy. The research design was used in this research is shown in Table 1.

RESULTS

The pretest and posttest data in both groups were used to measure the increase in students' mastery of concepts in the Basics of Analytical Chemistry course. The data recapitulation of student concept mastery in the two groups is presented in Table 2.

Table 2 shows that the average value of students' concept mastery pretensions in the experimental group (27) and control group (21). Meanwhile, the average posttest of concept mastery in the experimental group was 78 and the control group was 74. The results of the post-test scores for mastery of the concepts of the two groups were not significantly different. Based

Table 1. Quasy-Experimental Research Design

Subject	Pretest	Treatment	Posttest
Experimental	O1	X1	O_2
Control	O1	X_2	O_3

Remark :
X_1: Learning by using OE_3R
X_2: Learning by using conventiona method
O_1: Pretest results of the two groups
O_2: Posttest results of the experimental group
O_3: Posttest results of the control group

Table 2. Student Concept Mastery Data Recapitulation

Class	Highest Score	Lowest Score	Pretest Average Score	Std. Deviation	Posttest Average Score	Std. Deviation
Experimental	98	69	27	7,46	78	6,92
Control	93	46	21	8,28	74	12,17

Table 3. Normality and Homogeneity Testing Results

Testing	Significance Values			
	Experimental		Control	
	Pretest	Posttest	Pretest	Posttest
Normality	0,052	0,102	0,115	0,820
Homonegeity	0,074	0,090	0,074	0,090

Table 4. Independent Sample t-test Results

Class	Significance	Remark
Experimental Control	0,154	Less significant

Table 5. Recapitulation of Student Concept Mastery Data in the Experimental Group

Treatment	Average Score	Number of students with scores ≥ C	Number of students with scores ≤ C
Prior to learning with OE3R strategi strategy	22	0	21
Following learning with OE3R strategi strategy	78	21	0

on the standard deviation value, the score in the experimental group was lower (6.92) than the control group (12.17). This shows that the distribution of the experimental group's data is closer to the average value than the control group. Before testing the hypothesis, the pre-test and post-test value data were tested for prerequisites using normality and homogeneity tests. The results of the normality and pretest-posttest homogeneity tests are presented in Table 3. In addition, the two means of equality were tested to determine whether the pretest scores of the two groups were different or not. The results of the similarity test of two students' average mastery of concepts are presented in Table 4.

Table 3 shows that the pretest-posttest data normality test of mastery of the experimental and control class concepts was greater than 0.050. It can be concluded that the pretest-posttest data on concept mastery in both groups were normally distributed. The homogeneity test showed a significant number of more than 0.050 in both groups, both pretest, and posttest. This shows that the pretest-posttest data of the two groups has a homogeneous variant. Based on Table 4, the results of the significance of the independent sample t-test mean the students' concept mastery pretest (0.154) is greater than 0.050. It can be concluded that both groups have the same initial concept mastery.

The post-test was conducted to see the increase in students' mastery of concepts after being taught the OE3R strategy in the Basics of Analytical Chemistry course. The data recapitulation of concept mastery in the experimental group is presented in Table 5.

Table 6. ANCOVA Test Results

Group	Gain Score Avg	Hypothesis Testing	
		Sig.	Remark
Experimental	0,72	0,000	H_0 rejected
Control	0,64		

Based on Table 5, the average value of students' concept mastery after learning with the OE3R strategy (78) was higher than before learning with the OE3R strategy (22). This is supported by the increase in the number of students who scored C before studying with the OE3R (0) strategy and after studying with the OE3R (21). This shows that there is an effect of implementing the OE3R strategy on concept mastery.

To prove this statement, a hypothesis test was conducted after the pre-test and post-test data prerequisite tests for both groups were carried out. Test the hypothesis using the one-way between-group ANCOVA test which is presented in Table 6.

Table 6 shows that the hypothesis test has a significance value (0.000) smaller than 0.050, so H_0 is rejected and H_1 is accepted. It can be concluded that there are differences in the results of mastery of concepts for students who study with the OE3R strategy and conventional strategies in the Basics of Analytical Chemistry course.

DISCUSSION

Concept mastery is critical at every level of learning. Students' mastery of concepts demonstrates their ability to learn. The study's findings were analyzed using pretest and posttest scores for both the group taught using the OE3R strategy and the group taught using the conventional strategy. The pretest results indicated that both the experimental group (27) and the control group (21) possessed limited conceptual mastery. Following the collection of pretest data, an initial similarity test was conducted; the average pretest data obtained a significance value of 0.154, which is greater than 0.050. This demonstrates that the data for both groups are identical. It can be concluded that both groups possess the same capacity for mastering the initial concept prior to engaging in learning.

For four meetings on Acid-Base Titration and Oxidimetry materials, the experimental group used the OE_3R strategy and the control group used the conventional strategy. Following learning, a post-test was administered to assess students' conceptual mastery as a result of the strategy's implementation. The post-test results in the group taught using the OE_3R strategy (78), compared to the group taught using the conventional strategy (74). The pretest and posttest results were analyzed for normality and homogeneity. The normality test revealed that the pretest and posttest significance values were greater than i0.050 in both groups. These findings are also consistent with the homogeneity test. It can be concluded that pretest and posttest data were normally distributed and had homogeneous variances in both groups. Due to the fact that the data were normal and homogeneous, the hypothesis test was determined using a one-way group-between ANCOVA test.

Because the significance value of .000 was less than .050, H_0 was rejected and H_1 was accepted. This demonstrates that the results of student concept mastery differ between groups taught using the OE3R and conventional strategies. This is reinforced by the importance placed on concept mastery in the group taught using the OE3R strategy (78), as opposed to the group taught using the conventional strategy (74). Additionally, the experimental group achieved a higher level of conceptual mastery than the control group. However, the two groups' concept mastery scores were not significantly different. According to the standard deviation, the experimental group had a lower value (6.92) than the control group (12.17). This demonstrates that the experimental group's data distribution is closer to the mean value than the control group's data distribution.

The experimental group's post-test results improved before and after learning the OE3R strategy. Before learning the OE3R strategy, the test results were 22; after learning the OE3R strategy, the test results were 78. This was demonstrated by the increase in the number of students who managed to earn a C before and after studying with the OE3R strategy (0). (21). This demonstrates that combining inquiry-based learning with the OE3R strategy effectively increases students' conceptual mastery in the Basics of Analytical Chemistry course.

The essence of learning, according to Jerome S. Bruner, is how students actively select, retain, and transform information. The emphasis is on the information obtained and the actions taken to reach an understanding for him. This is consistent with David Ausubel's view that students can discover information (concepts, principles, and theories) on their own,

resulting in the acquisition of knowledge through discovery. According to David Ausubel, learning can be classified into two dimensions: how information or material is presented to students and how students relate the information or material to their existing cognitive structure. If students can connect new information to prior knowledge, meaningful learning has occurred. Meaningful learning occurs when the information students receive is organized in accordance with their cognitive structure, allowing students to make connections between the two.

According to Jerome S. Bruner and David Ausubel's learning theory, the difference in students' conceptual mastery between the two groups is due to a variety of factors. To begin, when students learn using the OE3R strategy, they have a more meaningful learning experience than when they learn using traditional methods. During the orientation stage of learning, students are taught to connect newly acquired information to previously held knowledge in their cognitive structure. The facts presented during the orientation stage pique students' interest. This creates a conflict in the students' cognitive structure. Students collect and process evidence or facts obtained during the exploration to explanation stage into more understandable forms (data, tables, graphs, and the like). Additionally, students gradually construct their own knowledge and experience during the OE3R strategy stage. Students are taught to connect previously acquired knowledge in order to form a complete concept.

The knowledge gathered will be relevant for a long period of time if the initial concept and the new concept being explored are connected (Septiani, 2014). Additionally, it demonstrates that kids are gaining knowledge. The OE3R technique develops physical and mental skills necessary for effective learning. Students are encouraged to research challenges using the OE3R method. These activities encourage students to actively search for solutions on their own. Students conduct experiments to gain a better understanding of chemistry by employing three levels of representation. These investigative activities will engage children and encourage them to develop systematic and fact-based concepts.

Second, students taught the OE3R technique are more mature in their application and application of concepts. Students' learning activities require them to use their entire knowledge base. Then they encounter new obstacles with the same material. These responsibilities are carried out throughout the development of the OE3R plan. Students use acquired information autonomously during the OE3R level. Additionally, students might apply their newly acquired knowledge to develop their own ideas or creativity. These activities assist students in resolving problems through the use of prior knowledge.

Students who study in the conventional manner are more likely to learn less. Students are unable to build and relate their information and experiences autonomously. As a result, students lacked a complete concept and cannot function for an extended period of time. Additionally, pupils have a proclivity for memorizing instructor knowledge. The difficulties diverted students' attention away from conceptual mastery. The average posttest score for the experimental group (78) is greater than the control group's (74) (refer to Table 4.5). The modification is small. The standard deviation for the experimental group is 6.92, whereas the standard deviation for the control group is 12.17. (Table 4.5). The distribution of data in the experimental group is closer to the mean than in the control group. Additionally, this sort of teaching causes students to be less concerned, indifferent, and uninterested (Saavreda, 2012).

OE3R is an inquiry-based learning technique. According to the NSES (National Science Education Standard), inquiry is a collection of interconnected processes by which scientists gain an understanding of nature and conduct investigations. According to Slavin, students must be actively participating in the learning process and become the focal point of learning activities in class. The application of inquiry enables students to learn in a discovery-oriented manner under the guidance and instruction of teachers/lecturers, ensuring that students grasp the idea completely (Perdana, 2018). Students will be presented with pertinent assignments to perform either in groups or individually. Students' cognitive conflict increases as a result of discussion activities in inquiry-based learning (Barrouillet, 2015). Students engaged in discussion activities based on data gathered to demonstrate knowledge of the idea (Sari, 2017). The student exercises are designed to help them independently solve problems and form conclusions. The OE3R technique requires students to actively seek out information. It is a visual illustration of how scientists acquire knowledge or concepts. Inquiry necessitates a range of hypotheses, employs critical and logical reasoning, and investigates alternative explanations (NRC, 1996). Additionally, the OE3R technique incorporates physical and mental exercises that promote students' mental and cognitive development (Sutrisno, 2020).

This is consistent with the findings of Sartika (2018), who found that the inquiry-based learning model (learning cycle) can increase students' conceptual mastery by 34 percent in the medium category and by 66% in the low category. The purpose of inquiry-based learning (the learning cycle) is to provide chances for students to develop their own knowledge and experiences via meaningful engagement with information (Smallhorn, et al, 2015). Constructing knowledge and experience requires students to study and think independently and collaboratively in order to master the capabilities required for learning (Fitriyani, et al, 2016).

CONCLUSION

According to the findings of this study, there are disparities in the results of students' conceptual mastery between the group that used the OE3R method and the group that used the conventional strategy in the Basics of Analytical Chemistry course. Additionally, the OE3R method improves students' conceptual mastery in the Basics of Analytical Chemistry course. This is corroborated by the fact that the post-test scores for the group taught using the OE3R technique were much higher than those for the group taught using the conventional strategy. Additionally, this is demonstrated by the increase in the number of students receiving C grades prior to and following the implementation of the OE3R method.

It is necessary to pay attention to the time allocation given for the implementation of the OE3R strategy (especially at the exploration, explanation, and elaboration stages) so that students are able to construct concepts independently, correctly, and completely.

REFERENCES

Andrianie, D., Sudarmin & Wardani, S. (2018). Representasi Kimia untuk Mereduksi Miskonsepsi Siswa pada Materi Redoks melalui Penerapan Model Pembelajaran Inkuiri Terbimbing Berbantuan LKS. *Chemistry in Education*, *7*(2), 70–76. https://doi.org/10.1111/j.1949-8594.1902.tb00418.x

Barrouillet, P. N. (2015). Theories of cognitive development: From Piaget to today. *Development Review Elsevier*, *38*, 1-12.

Eisenkraft, A. (2003). Expanding the 5E model. *The Science Teacher, 70*(6), 56"59.

Enger, S.K. & Yager, R.E. (2009). *Assessing Student Understanding in Science: A Standard-Based K-12 Handbook*. California: Corwin A SAGE Company.

Fitriyani, S., Sudin, A., & Sujana, A. (2016). Penerapan Model *Learning Cycle* pada Materi Sumber Daya Alam untuk Meningkatkan Hasil Belajar Siswa Kelas IV A SDN 1 Depok Kecamatan Depok Kabupaten Cirebon. *Jurnal Pena Ilmiah*, *1*(1), 511-520.

Hanson, R. (2014). Using Small Scale Chemistry Equipment for The Study of Some Organic Chemistry Topics- A Case Study in an Undergraduate Class in Ghana. *Journal of Education and Practice*, *5*(18), 59-64.

Hanson, R. (2017). Enhancing Students' Performance in Organic Chemistry Through Context-Based Learning and Micro Activities-A Case Study. *European Journal of Research and Reflection in Educational Sciences*, *5*(6).

Haryani, S., Prasetya, A.T., & Wardani, S. (2007). Penugasan Perencanaan Percobaan pada Praktikum Dasar-dasar Kimia Analitik untuk Meningkatkan Keterampilan Proses Sains Mahasiswa Calon Guru. *Seminar Nasional kerjasama UNDIP-UNNES-UNS*, (Oktober).

Kurniawati, I.D. & Diantoro, M. (2014). Pengaruh Pembelajaran Inkuiri Terbimbing Integrasi *Peer Instruction* terhadap Penguasaan Konsep dan Kemampuan Berpikir Kritis Siswa. *Jurnal Pendidikan Fisika Indonesia*, *10*(1), 36-46.

Pahriah & Hendrawani. (2018). Efektifitas Penggunaan Modul Multipel Representasi Berbasis Inkuiri Pada Materi Laju Reaksi Terhadap Pemahaman Konsep Calon Guru Kimia. *Prosiding Seminar Nasional LPP Mandala*, (September).

Pedaste, M., Maeots, M., Siiman, de Jong., van Riesen, S. A. N., Kamp, E. T., Manoli, C. C., Zachria, Z. C. Z., & Tsourlidaki, E. (2015). Phases of Inquiry-based Learning: Definitions and the Inquiry Cycle. *Educational Research Review*, 14, 47-61.

Perdana, R. & Rubiyadi, R. (2018). Enhancing students' cognitive outcome in chemistry by guided inquiry learning models. *International Journal of Sciences: Basic and Applied Research*. *37*(4), 41-51.

Samara, N.A.H. (2016). Effectiveness of Analogy Instructional Strategy on Undergraduate Student's Acquisition of Organic Chemistry Concepts in Mutah University, Jordan. *Journal of Education and Practice*, *7*(8).

Sari, D.J., Fadiawati, N., & Tania, L. (2017). Efektivitas e-book Interaktif Asam Basa Berbasis Representasi Kimia dalam Meningkatkan Pemahaman Konsep. *Jurnal Pendidikan dan Pembelajaran Kimia*, *7*(2), 237-250.

Sartika, R. P. (2018). Peranan Model Siklus Belajar 5E dalam Meningkatkan Pemahaman Konsep Sifat Koligatif Larutan. *Jurnal Kimia dan Pendidikan*, *3*(2), 157-171.

Sastrika, I. A. K., Sadia, I. W., & Muderawan, I. W. (2012). Pengaruh Model Pembelajaran Berbasis Proyek terhadap Pemahaman Konsep Kimia dan Keterampilan

Berpikir Kritis. *e-Journal Program Pascasarjana Universitas Pendidikan Ganesha*, *3*.

Septiani, D. & Sumarni, W. (2014). Efektivitas Model Inkuiri Berbantuan Modul Dalam Meningkatkan Pemahaman Konsep Dan Keterampilan Generik Sains. *Jurnal Inovasi Pendidikan Kimia*. *8*(2), 1340-1350.

Smallhorn, M., Young, J., Hunter, N., & da Silva, K. B., (2015). Inquiry-based learning to improve student engagement in a large first year topic. *Student Success*, *6*(2), 65-71. https://doi.org/10.5204/ssj.v6i2.292

Supasorn, S. & Promarak, V. (2015). Implementation of 5E Inquiry Incorporated with Analogy Learning Approach to Enhance Conceptual Understanding of Chemical Reaction Rate for Grade 11 Students. *Chemistry Education Research and Practice, 16*(1), 121-132. https://doi.org/10.1039/c4rp00190g

Sutrisno. (2018). OE_3R (Orientasi-Eksplorasi-Eksplanasi-Elaborasi-Refleksi): Sebuah Inovasi Strategi Pembelajaran Sains-Kimia Berbasis Inkuiri. *Seminar Nasional Kimia dan Pembelajaran (SNKP)*, (November), 48-60

Sutrisno, Nanda, G. A. M., & Widarti, H. R. (2020). *The effectiveness of inquiry based learning with OE_3R strategy for conceptual understanding of molecular shape of high school students '*. AIP Conference Proceedings **2215**, 020025 (2020); https://doi.org/10.1063/5.0000620 (April).

Sutrisno, Muchson, M., Widarti, H. R., & Sulistina, O. (2018). Miskonsepsi Sifat Keasaman Larutan Garam Para Guru Kimia dan Rekonstruksi Konseptualnya. *Jurnal Pembelajaran Kimia*., *3*(2), 10-18.

Talanquer, V. (2011). Macro, Submicro, and Symbolic: The many faces of the chemistry "triplet". *International Journal of Science Education*, *33*(2), 179-195.

WAEC. (2015). Chief Examiner's Report- Chemistry. *Accra: West African Examinations Council*.

Wenning, C. J. (2015). Level of Inquiry: Hierarchies of Pedagogical Practices and Inquiry Processes. *Journal Physic Teacher Education*, *2*(3), 3-11.