JPPIPA 9(1) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

The Effect of the Discovery Learning Model with a Scientific Approach on Student Representation Ability in the Buffer Solution

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Received: April 15, 2024
Revised: June 10, 2024
Accepted: June 25, 2024
Published: June 30, 2024

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DOI: 10.29303/jppipa.v10i6.7389

Abstract: This study aims to investigate the impact of the discovery learning model with a scientific approach on students' ability to represent macroscopic, submicroscopic, and symbolic aspects of buffer solutions. This study is quantitative research of the quasi-experimental type, utilizing a one group pretest-posttest design. The sampling technique employed is saturated sampling, where the entire population in the study becomes the research sample, consisting of 44 students from Bala Keselamatan Palu High School. The instrument used to measure the three abilities of student representation employs six essay questions, with each degree of representation assessed by two questions. Prior to usage, the six questions are initially verified by an expert of chemical representation abilities. The data analysis techniques used consist of descriptive data analysis and inferential data analysis. The results of the descriptive data analysis indicate that students' representational abilities have improved after participating in learning using the discovery learning model with a scientific approach. The ability of macroscopic representation has a higher average value and percentage of achievement indicators compared to symbolic and submicroscopic representation abilities. The inferential statistical analysis results indicate that the significant value of the Wilcoxon test is 0.000. The value is smaller than the significance level of 0.05, hence it can be concluded that the discovery learning model with a scientific approach influences students' representation abilities.

Keywords: Discovery Learning Model; Scientific Approach; Representational Ability.

Introduction

Chemistry is a component of the natural sciences discipline. The field of chemistry seeks to comprehend the properties and transformations of matter occurring in the natural world (Alam, 2021). Many basic concepts in chemistry are abstract. This abstract concept is usually difficult for students to understand if the teacher does not use the right learning model and approach (Andriani, 2023). The basic concepts of abstract chemistry can be studied using visualization in the form of chemical representations. Therefore, representation ability is important for every student to have (Iwuanyanwu, 2021).

Representation ability can be interpreted as students' ability to transfer and connect between macroscopic phenomena, submicroscopic and symbolic worlds (Kapici, 2023). When students can represent into three levels of representation, chemistry will be easier to understand (Habig, 2020). The ability to solve problems in chemistry learning using three levels of chemical representation can indicate student success in the chemistry learning process (Farida et al., 2018).

Students who have high representation skills can master the performance of representation competencies

How to Cite:
Santoso, T., Ahmar, D. S., Tukaedja, S. V., & Haetami, A. (2024). The Effect of the Discovery Learning Model with a Scientific Approach on Student Representation Ability in the Buffer Solution. *Jurnal Penelitian Pendidikan IPA*, *10*(6), 3296–3302. https://doi.org/10.29303/jppipa.v10i6.7389

which include: the ability to use representations to describe and explain chemical phenomena, analyze, and make relationships to patterns of certain representation features(Torres et al., 2021); and using its representations and features in social situations of observed chemical phenomena (Tao et al., 2021). In chemistry, the ability of representation can be understood by involving three levels of representation, namely the macroscopic, submicroscopic, and symbolic levels. The macroscopic level deals with students in representing abstract phenomena or phenomena that can be encountered and found in everyday life such as color changes in a chemical reaction that can be observed through the five senses. The submicroscopic level deals with phenomena in chemistry that are difficult to directly observe such as electron motion, molecular shape, and number of atoms. The symbolic level relates to symbols in chemistry which can be chemical equations, reaction mechanisms, graphs, and so on (Ahmar et al., 2020; Azzajjad et al., 2020).

According to Nugrahaeni et al., (2017), the ability of chemical representation can be developed in various learning models, one of which is the discovery learning model. The Discovery Learning model is a series of learning activities that involve the maximum of all students' abilities to search and investigate systematically, critically, logically, analytically so that they can formulate their own discoveries (Muhali & Sukaisih, 2023). In chemistry learning, teachers are expected not only to provide as much knowledge as possible to students, but are able to stimulate thinking, being scientific and creative as well as student responsibility for daily events relevant to chemistry lessons (Ong et al., 2020). This can be applied to the discovery learning model. It can be seen from the advantages of this learning model that teachers do not directly present learning materials, but students are given the opportunity to find a problem and can find a solution (Scholkopf et al., 2021).

Learning models and approaches can be said to create an active classroom atmosphere if there is interaction between students and teachers and students with students(Dakhi, 2022). On this basis it can be said that learning models and approaches are very important in a learning activity. In classroom learning, discovery learning models can be paired with scientific approaches (Lee & Perret, 2022). The Discovery learning model oriented to a scientific approach is one way to be able to improve the ability to find yourself, investigate yourself in solving student problems in science subjects(Wei et al., 2019). Through this learning model, students are encouraged to be active in exploring and discovering their own knowledge through learning experiences (du Plessis, 2020). This learning model also encourages active student engagement and the use of critical thinking (Prince et al., 2020). Meanwhile, the scientific approach in learning is an approach that emphasizes the use of observation, observation, experimentation, and scientific reasoning (Kaushik & Walsh, 2019). By employing a scientific methodology, students can be guided to independently discover and explore to resolve problems. Consequently, the implementation of this scientific approach can enhance student learning results (Schunk & DiBenedetto, 2021).

The level of difficulty in learning chemistry is the basis for the importance of analyzing more deeply the materials in chemistry learning (Chen et al., 2020). Buffer Solution material is a subject in chemistry learning that can be used to develop students' representation skills. This material guides students to explore chemical topics linked to solutions that have the ability to resist changes in pH (Baldwin, 2021).

Based on observations at SMA Bala Keselamatan Palu in class XI with a total of 44 students, who studied using the 2013 curriculum, it was found that there were 32 people who had not met the minimum completeness criteria score of 68. In classroom learning, teachers use lecture methods and demonstration methods, but students seem passive, less motivated, and even less interested in following learning because they do not understand chemistry thoroughly. Most students find it difficult to understand chemistry lessons that are influenced by abstract and calculation-related characteristics of chemistry (York & Orgill, 2020). Some students find it difficult to define the meaning of chemistry, solve calculation problems and find it difficult to relate chemistry to everyday life. This is because students' higher order thinking skills are still lacking. Based on these conditions, the author is interested in applying the discovery learning model using a scientific approach to improve the representation ability of students in class XI at SMA Bala Keselamatan Palu. The application of this model and approach, it is expected that students can master and even show success in the process of learning chemistry.

Method

This research is quantitative research that uses numerical data obtained from measurements. This type of research is pseudo-experimental research, where it is carried out with treatment, impact measurement, experimental units but does not use random assignments to create comparisons to conclude changes caused by treatment (Gopalan et al., 2020). The design used in this study was one group pretest posttest design.

Table 1. Research Design

Pretes	Treatment	Posttest
O_1	X	O_2

The population in this study was all eleventh-grade students at SMA Bala Keselamatan Palu as many as 44 people. The sampling technique uses saturated sampling, which is a sample that involves all members of the population into a research sample. The treatment given to the research sample is chemistry learning applying a discovery learning model with a scientific approach, as an independent variable, while the dependent variable is the ability of student representation in the buffer solution.

The instrument used to measure three types of levels of chemical representation ability in the buffer solution is in the form of 6 essay questions. Each type of representation ability level is measured by 2 questions. The level of macroscopic representation is measured by the student's ability to analyze the role of the buffer solution in the body of living things and analyze the properties and working principles of the buffer solution. The level of submicroscopic representation is measured by the student's ability to analyze the buffer properties of a solution with the addition of strong acids and strong bases and the student's ability to determine solutions that have buffer properties. The level of symbolic representation is measured by the student's ability to analyze the pH of a buffer solution with the addition of a small amount of acid or strong base. Before the instrument is used, the instrument is validated by an expert evaluating the measurement of chemical representation ability.

Results and Discussion

Data analysis techniques used to see the influence of discovery learning models with a scientific approach on students' representation abilities in buffer solution learning are descriptive analysis and inferential analysis. Descriptive analysis is used to find out a picture of students' representation abilities. Descriptive analysis includes number of students, maximum grade, minimum grade, grade point average, and standard deviation. Meanwhile, inferential analysis is used to see the effect of the treatment given. Inferential analysis using paired sample t-test. Data from descriptive statistical analysis of students' representation ability can be seen in Table 2.

Table 2. Results of Descriptive Statistical Analysis of Representation Ability

Statistics	Pretest	Posttest
Number of students	44	44
Minimum value	4	33
Max Value	46	83
Average rating	26,52	60.32
Standard deviation	9,847	13.160

Based on the data in Table 2, it can be seen that students' representation ability increased from 26.52 to 60.32. Similarly, each level of students' representation ability also improved (see Table 9).

Macroscopic Representation Capabilities

Data on the results of the analysis and categories of students' macroscopic representation abilities during the pretest and posttest can be seen in Table 3 and Table 4.

Table 3. Results of Descriptive Statistical Analysis of Macroscopic Representation Ability

Statistics	Pretest	Posttest
Number of students	44	44
Minimum value	0	0
Max Value	63	100
Average rating	24.15	69.32
Standard deviation	20.065	27.287

Table 4 Macroscopic Representation Capability Categories

Value	Category	Frequency	
		Pretest	Posttest
81 – 100	Very High	0	13
61 – 80	High	4	16
41 – 60	Enough	4	8
21 – 40	Low	19	3
0 – 20	Very Low	13	0

The ability of macroscopic representation in buffer solution learning, in Table 9 shows how students write down the results of observations of a phenomenon in the blood solution observed by the eye. Students recorded the number of drops of acid added to the blood and changes in blood pH. Then students explained using the analysis of the relationship between the role of buffer solutions in the body of living things such as how the role of blood as a buffer solution can maintain blood pH.

The ability of macroscopic representation in chemistry learning is related to the observation of the properties of substances, phase changes, chemical reactions, and various other chemical phenomena that can be observed with the naked eye (Stowe et al., 2019). This ability is important for students because it helps students understand the relationship between chemical concepts and observable daily events or experiments (said Mahmoud Ismail, 2020). This ability is also related to the ability to observe and describe the physical and chemical properties of a substance, such as color, odor, state of matter (solid, liquid, gas), and thermal conductivity, in addition, it also includes the ability to understand the phase changes of substances, such as seeing ice melting into water at room temperature or water boiling into water vapor and other processes that involve sensing subjects (Nowak & Jakubczyk, 2020).

Submicroscopic Representation Capabilities

The ability to portray submicroscopic phenomena is one of the abilities that helps students understand various visualizations that introduce scientific concepts and processes that cannot be observed with the naked eye (Savec et al., 2016). The results of the descriptive statistical analysis and the students' ability to describe submicroscopic phenomena in this study may be observed in Table 5 and Table 6.

Table 5. Results of Descriptive Statistical Analysis of Submicroscopic Representation Ability

Statistics	Pretest	Posttest
Number of students	44	44
Minimum value	0	13
Max Value	88	100
Average rating	21.31	44.60
Standard deviation	22.161	21.465

TAbel 6. Categories of Submicroscopic Representation Ability

Value	Category	Frequency	
		Pretest	Posttest
81 – 100	Very High	1	1
61 – 80	High	2	12
41 – 60	Enough	4	7
21 – 40	Low	11	10
0 – 20	Very Low	26	14

Symbolic Representation Capabilities

The ability of students to express symbols is emphasized in the depiction of chemistry through the presentation of words, images, data, chemical formulas, diagrams, reaction equations, and other computational forms. This ability can enhance students' understanding of macroscopic and submicroscopic representations (Ahmar et al., 2020). The results of the analysis and the categories of students' symbolic representation abilities during the pretest and posttest may be observed in Table 7 and Table 8.

Table 7. Results of Descriptive Statistical Analysis of Symbolic Representation Capabilities

Statistics	Pretest	Posttest
Number of students	44	44
Minimum value	0	0
Max Value	88	100
Average rating	34.09	67.05
Standard deviation	22.290	29.909

Table 8: Categories of Symbolic Representation Ability

Value	Category	Frequency	
		Pretest	Posttest
81 – 100	Very High	1	13
61 – 80	High	4	15
41 – 60	Enough	11	6
21 – 40	Low	18	3
0 – 20	Very Low	10	7

Based on the results of the descriptive statistical analysis, it can be determined that the average ability of students in each level of representation, from lowest to highest, is the ability in submicroscopic, symbolic, and macroscopic representation. The percentage of proficiency for each indicator of representational ability measured in this study can be seen in tables 9, 10, and 11. Based on the data in the table, it is also evident that the ability to depict submicroscopic phenomena is an indicator that has a lower percentage value compared to other representation abilities. Regarding this matter, (Wulandari et al., 2019) state that understanding the concept of chemistry involves a significant challenge for students when it comes to representing submicroscopic levels. Generally, students rely on memorization strategies, which can be considered inadequate as they do not allow students to connect macroscopic phenomena with submicroscopic ones, ultimately making it difficult for students to imagine how the process and structure of a substance can react. Another difficulty encountered by students is the lack of visualization in depicting molecular phenomena.

Table 9. Analysis of Proficiency in Macroscopic Representation Ability Indicators

Macroscopic Level Representation Question Indicator	Question number	∑ students who provide complete and accurate answers	%	Criteria
Formulating an observation of a chemical phenomenon that can be perceived by the senses. An example could be an experience from everyday life. Example: Analyzing the role of buffer solutions in living organisms, such as how blood acts as a buffer solution that maintains the pH of the blood.	1	25	56.81	Good
Observation allows us to understand the components of acid and base buffer solutions by seeing the pH changes of the solution when a small amount of acid or base is added.	2	22	50	Good

Table 10. Analysis of Proficiency in Submicroscopic Representation Ability Indicators

Macroscopic Level Representation Question Indicator	Question number	∑ students who provide complete and accurate answers	%	Criteria
Presenting the structure of a buffer solution containing a weak acid and its conjugate base to explain the working principle of the solution when a strong acid is added.	3	9	20.45	Extremely low
Presenting several solutions that possess buffering properties and explaining their preparation by determining the initial pH of the solution and the pH when a small amount of acid or base is added.	4	7	15.90	Extremely low

Table 11. Analysis of Proficiency in Symbolic Representation Ability Indicators

Macroscopic Level Representation Question Indicator	Question number	∑ students who provide complete and accurate answers	%	Criteria
Presenting tables, images, graphs, and components of acid and base buffer solutions.	5	27	61.36	Good
Writing chemical formulas, diagrams, and reaction equations using calculations.	6	18	40.90	low

The ability to depict macroscopic phenomena is the highest among other representation abilities, as it is most commonly utilized by students. In daily life, there are numerous chemical phenomena that can be utilized as learning tools by students to quickly comprehend chemical materials. Unlike symbolic representation, this ability specifically refers to a student's capacity to comprehend chemical symbols such as chemical formulas, diagrams, and the like. By providing students with regular practice, their ability to develop in this area will improve. Furthermore, Constable et al., (2019) added that students' understanding of chemical symbols and specific concepts also depends on an individual's ability to communicate and comprehend specialized terms in a particular language. Some groups in society have traditional symbolism associated with chemical elements or chemical concepts.

In addition to doing descriptive statistical analysis, this study also performed inferential statistical analysis to determine the presence or absence of the influence of the discovery learning model using a scientific approach on students' representational abilities. The testing begins with a prerequisite test consisting of normality test and homogeneity test. The normality of the data was assessed using the One Sample Kolmogorov Smirnov test, which yielded a significance value of 0.004 for the pretest data and 0.046 for the post-test data. Based on both facts, it can be said that the data in this study is not normally distributed. The homogeneity of data was tested using the homogeneity of variance test, and a significance value of 0.006 was obtained. The value indicates that the data is homogeneously distributed. Due to the data not meeting the requirements for parametric testing, the hypothesis test in this study was conducted using non-parametric analysis, specifically the Wilcoxon test. The Wilcoxon analysis results indicate that the significance value of the data is 0.000. The value indicates that the alternative hypothesis in this study is accepted, so it can be said that there is an influence of implementing the discovery learning model using a scientific approach on students' representation abilities.

The discovery learning model facilitates student learning through active engagement with concepts and principles, with teachers encouraging students to gain experience and engage in activities that enable them to discover concepts and principles for themselves (Swastika et al., 2022). To maximize this learning model, it is necessary to pair it with a learning approach. This indicates that the discovery learning model can have a greater impact on students' understanding.

Conclusion

Based on the findings of the research and data analysis conducted, it can be concluded that the discovery learning model with a scientific approach has an influence on students' representation abilities, including their abilities in macroscopic, submicroscopic, and symbolic representation. The results of the descriptive analysis for each level of representation indicate that, in sequential order from highest to lowest average value and percentage of indicator achievement are: the abilities of macroscopic, symbolic, and submicroscopic representation.

Acknowledgments
The author thanks the Chemistry Education Study Program, Faculty of Teacher Training and Education, Tadulako University.

Author Contributions

Tri Santoso, Dewi Satria Ahmar, Sindy Valesia Tukaedja: conceptualization, analysis, methodology, discussion, conclusion, visualization, investigation, writing–original draft, and proofreading; Aceng Haetami: review and editing.

Funding

This research received no external funding

Conflicts of Interest

The Authors declare no conflict of interest regarding the publication of this paper.

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