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Improving Students' Chemical Literacy Ability on Equilibrium Material Using Chemical Literacy-Based Teaching Materials

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Abstract: Trends in science education policy in the 21st century emphasize the importance of scientific literacy as a transferable outcome. This study aims to analyze the use of chemical literacy-based teaching materials in equilibrium material to improve students' chemical literacy ability. The results showed that the chemical literacy ability of students who were given chemical literacy-based teaching materials was higher than students who were given general chemistry teaching materials. The biggest difference in students' chemical literacy ability is at the nominal level of scientific literacy, which is 8.24 points; followed at the conceptual scientific literacy level of 6.74 points and at the functional scientific literacy level with a difference of 5.61 points.

Keywords: teaching materials, chemical literacy, equilibrium

1. INTRODUCTION

Science education has an important role in preparing quality human resources in the face of globalization. The process and learning of science can produce quality human beings by showing scientific awareness (scientific literacy) and high-level thinking skills that can create human resources capable of critical thinking, creative thinking, decision making and problem solving [1].

Chemistry is included in the science family and is one of the branches of natural science that includes concepts, rules, laws, principles, and theories [2]. The Chemistry Education Study Program at the State University of Medan has a strong commitment to aligning the chemistry learning process with technological advances according to stakeholder needs.

Chemistry is built on a product, process, and scientific attitude. Chemistry cannot be learned simply through reading, writing, or listening. Mastery of chemistry is measured through the ability to master a collection of chemical knowledge and skills to do scientific work [3].

The development of digital technology affects various aspects of education including learning strategies. The need for more flexible access to time, speed, methods and efficiency in learning creates innovative learning strategies that involve ICT. ICT-supported learning allows students to learn anything, anytime and anywhere is an advantage that facilitates the learning process [4].

The big challenge for the ideal education process is not only to prepare the nation's generation that is able to live today, but the generation that is equipped with the ability to live in the future. Challenges in the global era are increasingly complex and require problem solving with a critical mindset and full of creativity [5]. However, the main problem in learning in formal education (school) today is the low absorption capacity of students. In a more substantial sense, that the learning process until today still gives teacher centered and does not provide access for students to develop independently through discovery in their thinking process [6].

The facts show that in the learning process, especially in science learning, students tend to memorize concepts, theories, and principles without interpreting the acquisition process. As a result, students become less trained to think and use their reasoning power in understanding natural phenomena that occur or when facing problems [7].

Trends in science education policy in the 21st century emphasize the importance of scientific literacy as a transferable outcome [8]. In the 21st century, literacy ability are not only limited to the ability to read, listen, write and speak orally, but more than that, literacy ability are emphasized on literacy ability that are connected to one another in the current digital era [9].

Scientific literacy is defined as the ability to use scientific knowledge, identify questions and draw fact-based conclusions to understand the universe and make decisions about changes that occur due to human activities [1]. Scientific literacy is one of the parameters in determining the human development index which is strongly influenced by the quality of education [10].

Chemical literacy is related to how students can appreciate nature by utilizing the science/chemistry and technology they master. People who have chemical literacy understand the basic concepts of chemistry, can explain phenomena and solve problems in life using their understanding of chemistry, understand chemical innovations in social life and have an interest in chemistry [11]. Chemical literacy can be used as a forum for students to train high-level thinking where students relate to everyday phenomena [12].

Indonesia's scientific literacy ability is in the low category based on the 2015 *Programme for International Student Assessment* (PISA) study report. For scientific literacy, Indonesian students are ranked 62 out of 70 countries with a score of 403; for mathematical literacy, Indonesian students are ranked 63rd out of 70 countries with a score of 386 even for reading literacy is ranked 64th out of 70 countries with a score of 397 [1]. These results show that the average scientific literacy ability in Indonesia is only able to recognize basic facts, but has not been able to communicate and relate these abilities to various scientific topics, especially to apply concepts in life.

Many factors that can affect the low ability of chemical literacy include the education system, models, approaches, methods, learning strategies used, learning resources, learning styles and learning infrastructure. Therefore, the development of chemical literacy ability is not only influenced by the learning model but also the teaching materials used. This is in accordance with the research of Rusilowati and Safitri et al which showed that the use of teaching materials containing scientific literacy can improve scientific literacy ability [13] [14]. However, in reality the teaching materials used have not been supported to develop scientific literacy ability. This is in accordance with the results of the study [15] which shows that the science textbooks used do not contain a balanced component of scientific literacy. In addition, the presentation of the material used emphasizes the presentation of facts, concepts, principles, laws, theories and models and places more emphasis on the stage of remembering information through the questions presented [16].

Equilibrium material is one of the studies in a compulsory subject in the Chemistry Education Study Program, Chemistry Department, FMIPA, State University of Medan (UNIMED). Equilibrium material is studied in general in the Chemical Basics course and further studied in the special Kinetics and Equilibrium course. Equilibrium material discusses the concept of equilibrium which includes chemical potential, reaction isotherms, free energy and its relation to equilibrium constants and phase equilibrium which includes the Clausius clayperon equation, phase diagrams of uner systems, binary systems and their relation to azeotropic concepts and distillation principles, and ternary system diagrams, also its application in chemical systems that can be applied in life.

To improve students' abilities in learning chemistry, it is always necessary to change or innovate continuously so that they can achieve predetermined learning objectives, one of which is the ability of graduates who are sensitive to very fast information, so that ability are needed to be selective in choosing information according to what is needed. needed. Literacy ability can be trained through the educational process using a literacy-based learning model.

Scientific literacy develops through well-structured learning activities using targeted construction teaching materials in accordance with the objectives. Teaching materials that can be used by students as a source of independent learning have an important role in improving and developing abilities, including student literacy ability [5]. The existence of teaching materials to improve chemical literacy ability is expected to provide an optimum influence in the learning process to train students to find scientific knowledge independently [17], identify questions and analyze the meaning of the acquired knowledge [18].

2. METHOD

This research is a quasi-experimental research using Non-Equivalent Control Group Design which aims to determine the effect of applying learning using chemical literacy-based teaching materials to increase students' chemical literacy ability on equilibrium material. In this design, there are two groups of UNIMED Chemistry Education study program students who are used as research subjects, namely one group who gets learning using general teaching materials (control) and the other group is given learning using chemical literacy-based teaching materials (experiments).

The instrument used in data collection was a test of chemical literacy ability on equilibrium material that had met the test quality criteria including validity, reliability, level of difficulty and discriminating power of test items. Indicators of chemical literacy ability in this study are based on the level of chemical literacy, namely nominal scientific literacy, functional scientific literacy, and conceptual scientific literacy.

The research procedure was carried out through several stages, including: 1) the initial stage, namely giving a chemical literacy ability test (pretest) to determine students' initial abilities; 2) the second stage is the learning process where control class students are given learning using general teaching materials used while experimental class students are given learning using chemical literacy-based general teaching materials; 3) the final stage is giving a chemical literacy ability test (posttest) to determine students' chemical literacy ability after being given learning.

The data analysis technique used is descriptive analysis technique and inferential technique. Descriptive analysis technique was used to describe the data including the lowest, highest, average (mean) and standard deviation values. Inferential statistical techniques were used to test the research hypotheses using the t-test of two sample groups. Before testing the hypothesis, prerequisite tests were first carried out on the data using the normality test and homogeneity test.

3. RESEARCH RESULT

3.1 Data Description

Data on students' chemical literacy ability on equilibrium material were obtained based on the results of the pretest and posttest

Table 1. Data of initial chemical literacy ability (pretest)

Class	Level	Min	Max	Mean
Control	Nominal scientific literacy	15	57	45.36
	Functional scientific literacy	12	56	33.44
	Conceptual scientific literacy	6	50	23.13
Experiment	Nominal scientific literacy	18	58	48.13
	Functional scientific literacy	6	55	31.41
	Conceptual scientific literacy	4	50	22.81

Table 1, shows that the average students' initial ability (pretest) in the control class and the experimental class at the nominal level of scientific literacy are 45.36 and 48.13, respectively; at the level of functional scientific literacy are 33.44 and 31.41, respectively; and the level of conceptual scientific literacy is 23.13 and 22.81, respectively. These results indicate that students' initial literacy ability on equilibrium material based on the results of the pretest are still very low at the nominal scientific literacy level, functional scientific literacy, and conceptual scientific literacy level.

Table 2. Data of chemical literacy ability (posttest)

Class	Level	Min	Max	Mean
Control	Nominal scientific literacy	50	90	81.88
	Functional scientific literacy	40	80	74.69
	Conceptual scientific literacy	40	68	63.38
Experiment	Nominal scientific literacy	55	92	90.12
	Functional scientific literacy	46	90	80.30
	Conceptual scientific literacy	41	84	70.13

Table 2, shows the average chemical literacy ability of students (posttest) at the nominal scientific literacy level, for the control class it is 81.88 (competent) while for the experimental class it is 90.12 (very competent). At the level of functional scientific literacy, the control class obtained an average of 74.69 (competent enough) while for the experimental class an average of 80.30 (competent) was obtained. At the conceptual scientific literacy level, the control class obtained an average of 63.38 (less competent) while for the experimental class, the average obtained was 70.13 (competent enough).

3.2 Result of Normality Data Test

The normality test of students' chemical literacy ability data (pretests and posttests) was analyzed by Chi-square test (χ^2) at the significance level $\alpha = 0.05$.

Table 3. Result of normality test of pretest data

Class	Level	χ^2_{count}	χ^2_{table}
Control	Nominal scientific literacy	9.16	11.07
	Functional scientific literacy	8.68	
	Conceptual scientific literacy	5.95	
Experiment	Nominal scientific literacy	7.93	
	Functional scientific literacy	8.55	
	Conceptual scientific literacy	6.32	

Table 3, shows that the results of the normality test of the students' initial literacy ability data (pretest) for each class obtained the value of $\chi^2_{count} < \chi^2_{table}$ so that it can be concluded that the pretest data from each group has a normally distributed data distribution.

Table 4. Result of normality test of posttest data

Class	Level	χ^2_{count}	χ^2_{table}
Control	Nominal scientific literacy	10.16	11.07
	Functional scientific literacy	9.23	
	Conceptual scientific literacy	9.79	
Experiment	Nominal scientific literacy	5.95	
	Functional scientific literacy	9.70	
	Conceptual scientific literacy	10.45	

Table 4, shows that the results of the normality test of students' chemical literacy ability data (posttest) for each class obtained a value of $\chi^2_{count} < \chi^2_{table}$ so it can be concluded that the chemical literacy ability data (pretest) from each group has a data distribution that is normally distributed.

3.3 Result of Homogeneity Data Test

The homogeneity test of the data is intended to determine the difference in data variance from each group. The homogeneity of the data was analyzed using Fisher test (F-Test) at the significance level $\alpha = 0.05$.

Table 5. Result of homogeneity test of pretest data

Level	Class	(S^2)	F_{count}	F_{table}
Nominal scientific literacy	Control	170.56	1.51	1.82
	Experiment	169.25		
Functional scientific literacy	Control	152.45	1.26	
	Experiment	135.74		
Conceptual scientific literacy	Control	144.25	1.01	
	Experiment	95.54		

Table 5, shows that the results of the homogeneity test of the initial literacy ability data (pretest) at each level obtained the value of $F_{count} < F_{table}$ so it can be concluded that the initial literacy ability data (pretest) is at the nominal scientific literacy level, functional scientific literacy, and conceptual scientific level. literacy has the same variance (homogeneous).

Table 6. Result of homogeneity test of posttest data

Level	Class	(S^2)	F_{count}	F_{table}
Nominal scientific literacy	Control	15.36	1.75	1.82
	Experiment	10.48		
Functional scientific literacy	Control	91.36	1.73	
	Experiment	52.81		
Conceptual scientific literacy	Control	182.34	1.28	
	Experiment	141.94		

Table 6, shows that the results of the homogeneity test of students' chemical literacy ability data (posttest) at each level obtained the value of $F_{count} < F_{table}$ so that it can be concluded that the chemical literacy ability data (posttest) of students on balance material is good at the nominal level of scientific literacy, functional scientific literacy, as well as the level of conceptual scientific literacy have the same variance (homogeneous).

3.4 Result of Hypothesis Test

After the data analysis requirements were met both normality and homogeneity of the data, then hypothesis testing was carried out using the t-test of two sample groups at the significance level $\alpha = 0.05$.

Table 7. Result of hypothesis test

Level	t_{count}	t_{table}	Criteria
Nominal scientific literacy	5.598	2.013	Significant
Functional scientific literacy	3.381		Significant
Conceptual scientific literacy	4.985		Significant

Table 7, shows that the results of hypothesis testing on students' chemical literacy ability data (posttest) for each level obtained the value of $t_{count} > t_{table}$ so that statistically the hypothesis is accepted and it is concluded that students' chemical literacy ability are given learning using teaching materials based on chemical literacy materials the balance is higher than the chemical literacy ability of students who are given learning using general chemistry teaching materials both at the nominal scientific literacy level, functional scientific literacy, and conceptual scientific literacy level.

Table 8. Differences in chemical literacy ability

Level	Mean (Class)		
	Control	Experiment	Differences
Nominal scientific literacy	81.88	90.12	8.24
Functional scientific literacy	74.69	80.30	5.61
Conceptual scientific literacy	63.88	70.13	6.74

Table 8, shows the average difference in students' chemical literacy ability between the control class and the experimental class. The biggest difference in students' chemical literacy ability is at the nominal level of scientific literacy, which is 8.24 points; followed at the conceptual scientific literacy level of 6.74 points and at the functional scientific literacy level with a difference of 5.61 points. The difference in chemical literacy abilities of students in the control class and the experimental class is in line with the distribution of the components of scientific literacy that is good and balanced in the chemical literacy-based teaching materials used. The component of science as the body of knowledge is the component that should be found in most textbooks because it contains: (1) facts, concepts, principles and laws; (2) hypotheses, theories and models; and (3) asking students to remember knowledge and information.

4. CONCLUSION

The results showed that there were differences in chemical literacy ability between experimental class students and control class students. The results of hypothesis testing show that the chemical literacy ability of students who are given learning using teaching materials based on chemical literacy in equilibrium material (experiments) is higher than students who are given learning using general chemistry teaching materials (control). The biggest difference in students' chemical literacy ability is at the nominal level of scientific literacy, which is 8.24 points; followed at the conceptual scientific literacy level of 6.74 points and at the functional scientific literacy level with a difference of 5.61 points.

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