

Inquiry Learning Using Local Socio-Scientific Issues as Context to Improve Students' Chemical Literacy

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ABSTRACT

This study aimed to investigate applying inquiry learning using local Socio-scientific Issues (SSI) as a context on the students' chemical literacy; in this study, using a Quasi-experimental with a pretest-posttest design. There are two classes in this study, the experimental class, and the control class. The experimental class implemented with inquiry learning using local SSI context, while the control class implemented with a scientific approach. The sample consisted of 66 students in grade XI, which was determined by random sampling. Data were obtained through the Reaction Rate Chemical Literacy Test (RRCLT), which consisted of topics about coral reefs, volcanic eruptions, tropical forests, biofuel energy sources, and medical use of alcohol. Data analysis used a Paired sample *t*-test, Independent sample *t*-test. The result showed a difference in students' chemical literacy ability before and after the inquiry learning using local SSI context implementation. There was a difference in students' chemical literacy ability between the experimental and control class. The enhancement of students' chemical literacy on each experimental class topic was higher than the control class. This study suggests that inquiry learning in the local context of SSI should be applied in schools to improve students' chemical literacy skills.

Keywords: Chemical literacy, Socio-scientific issues, Inquiry learning, Reaction rates.

1. INTRODUCTION

The growing up of the 21st century requires students with several competencies, such as scientific and chemical literacy. Four domains characterize students who have literacy abilities, according to [1-2]. The first domain is knowledge of scientific and chemical content. Students have scientific ideas like they can carry out scientific investigations, use knowledge to explain phenomena, and explain reaction processes. The research showed by [3] that students apply thermochemical chemistry to explain the combi boiler phenomenon and explain it based on chemical processes. The second is chemistry in a context; chemically literate students should be able to use chemistry knowledge to explain and understand chemistry in everyday life, make decisions, engage in social arguments about chemical problems, and be involved in chemistry innovations. For example, students can utilize the acid-base concept's chemical knowledge in an effective decision-making process to understand the acid rain phenomenon [4]. The third domain is high order learning skills (HOLS), which refer to ask questions, investigate relevant information, and evaluate the pros/cons of debate. For example, students engage in debate about the use

of sodium benzoate using the concept of buffer solutions; in this debate activity, students will be active in finding credible sources and evaluating conflicting evidence from reliable sources [5]. The last domain is the affective aspect, and literate people must have a fair and rational attitude towards the chemical perspective. Literate students show an interest in chemical issues, especially in non-formal environments such as the mass media. Students can demonstrate their chemical literacy skills if the learning process is given a chemical context appropriate to daily life situations. For example, students showed an interest in transferring their thermochemical and thermodynamic knowledge into the real-life context of volcanic eruptions [3].

Unfortunately, students' chemical literacy skills are still low. Students not knowing chemistry concepts' application in everyday life and feeling their learning concepts are useless for their lives [6]. Several things cause these facts i.e, because the context in learning chemistry is not emphasized enough [7]. One interesting context that require HOLs and decision attitudes (according to literacy aspects) is SSI. It contains a controversial local SSI issue and provides a rich context for exploring science in the classroom [8]. It also related to science,

involved morals, and ethics [9-10]. SSI contextual learning provides opportunities for students to be actively involved in decision making, argue, and explore the relationship of social-science issues with other fields of science [11-13]. Learning chemistry with the SSI context can improve chemical literacy, critical thinking, and student collaboration [5].

Chemistry learning problems also exist at the level of students' understanding of reaction rates because students have not been able to connect it with students' lives [14]. One chemistry concept closed to students' life is the rate of reaction [15]. The context that can be related to the reaction rate topics is a local problem in Indonesia. Some contexts used in the reaction rate material are coral reefs, volcanic eruptions, tropical forests, biofuel energy sources, and medical use of alcohol [16]. For example, thermochemistry, chemical reactions, covalent bonds, intermolecular forces, the concept of stoichiometry exist in the context of biofuel energy sources [17]. Students investigate socio-scientific issues that are personally relevant and discuss, argue, or construct arguments/explanations for solving the problem.

The science learning approach that can be integrated with the SSI context is the inquiry approach. SSI's local-based investigations present problems relevant to students' daily lives and provide meaningful learning opportunities [18]. Inquiry learning effectively increases student motivation and has a positive impact on student attitudes in solving socio-scientific issues [18-19]. Based on previous studies related to inquiry learning using the context of the socio-scientific issue above, the research's objective is to investigate applying inquiry learning using local SSI context on the students' chemical literacy. The research objective was the answer to the research question were divided into three research questions. Firstly, is there a difference between students' chemical literacy ability before and after implementation? Secondly, is there a difference in students' chemical literacy ability between the experimental and control class, and thirdly, is there an enhancement in students' chemical literacy ability on each topic?

2. RESEARCH METHODS

2.1. Research Design and Sample

The type of research used in this study was quasi-experimental pretest-posttest design. The research sample was 11th-grade students. Convenience sampling was done to determine the school. After school was selected for research, the class was used as a research sample using random sampling techniques. The experimental class consists

of 32 students, while the control class consists of 34 students. Reaction rate chemistry literacy test (RRCLT) shows a reaction rate chemical literacy test before and after treatment. Inquiry learning using local SSI context applied in experimental class, the scientific approach applied in the control class. An initial test (pretest) was given before the inquiry learning using local SSI context in experimental class and scientific approach in the control class. At the end of learning, a final test (post-test) was conducted after the student participated in inquiry learning using the local SSI context in the experimental class and the control class's scientific approach.

2.2 Teaching Intervention

Inquiry learning using local socio-scientific issues context in this study used the Predict, Observe, Explain, Extend (POEE) that combine with inquiry activities [20], [21]. The experimental class's research procedure began with students writing down problems (Explorations) that exist in the discourse on the student's worksheet. Students then make questions related to problems that it has been written on the student's worksheet, besides students writing hypotheses from questions created (Predict). After that, students do some data collection (Observe) and explain the data collection results based on the hypothesis (Explain). The last research procedure is to strengthen understanding by working on existing student worksheets' existing problems (Extend). For example, in the second meeting, students learned about the initial concept of reaction rate and collision theory through the context of SSI coral reefs.

At the beginning of the lesson, students learn about the initial reaction rate and collision theory concept. Next, the teacher introduces the context of the SSI coral reef presented on the student worksheet. Students were given the task of reading discourses on local SSI coral reef topics on student worksheets. After that, students analyzed and wrote down the problems that existed in the context of coral reefs. This step was the Problem Exploration step, where students' knowledge and ideas about the context constructed. The teacher guides students in exploring problems in context. Their curiosity was stimulated by asking questions related to problems that students had written on the worksheets in class. Some of these include: How did the destruction of coral reefs react? What is the rate of formation of coral reefs?

Next, in the Prediction step, students make their hypothesis from the questions they have created. Learning activities were continued at the third meeting due to time constraints; at the Observe step, students conduct investigations to prove their hypothesis. Investigations were carried out in groups.

Then, a picture of the mechanism of "coral reef destruction" was displayed. After the picture was displayed, students write down the observation results. They debriefed with friends and teachers to elaborate on context-oriented questions. The teacher constantly guided, posed additional questions to students to receive their ideas. The teacher-guided students discussed controversial issues regarding the rules for detonating sea bombs that can disrupt coral reefs' preservation. While anticipating the responses, the teacher provided additional explanations whenever needed and guiding students' ideas and observation. Next, the students explained and related the correspondence between their predictions and observations in the Explain step. Later, the teacher asked students to communicate their opinions about the impact of sea bombs on preserving coral reefs. In the final step, namely the Extend step, students strengthen their understanding by solving the worksheets' problems.

The scientific approach in the control class began with the Observing step, students watching videos of iron rust. Furthermore, in the Asking step, the teacher guided students to make questions related to iron rust. Students asked questions to know more about the phenomenon they observed. Students wrote down questions on a worksheet. For example, how does rusting react? How the rate of rust rusting? Next, Collected information step, students answer the

questions they created. The teacher explained the reaction rate and collision theory related to iron rust while guiding students in gathering information. The teacher-guided students continuously in discussing with the group by processing the Associate step's information. Students processed information to find connections with other information in the group. Then, in the Communicating step, students explained the results of gathering information.

2.3. Research Instrument and Data Collection

The data were obtained from the reaction rate chemical literacy test (RRCLT). RRCLT was essay questions, which consisted of total item number under five local SSI topics (coral reefs, volcanic eruptions, tropical forest, biofuel energy sources, and medical use of alcohol). The researcher developed the reaction rate chemical literacy test (RRCLT) by synthesizing chemical literacy aspects according to [1-2,16]. The grid of RRCLT was presented in Table 1.

RRCLT validation has been done theoretically and empirically. Theoretical validation was conducted by two experts (chemistry educators). With their suggestion, RRCLT was revised. Then, RRCLT was tested empirically with 160 students out of the sample.

Table 1. The grid of RRCLT

Chemistry in context	Chemical content knowledge	HOLS	Item Number
Coral reef	Collision theory	Analyzing information	1b
Volcanic eruption	Defining reaction rate	Analyzing information	2a
	Defining reaction rate	Connected Information	2b
	Order and law of reaction rate	Connected Information	2c
	Defining reaction rate, collision theory	Making arguments	2d
Tropical forest	Defining reaction rate	Analyzing information	3a
	The factor that affecting reaction rate	Identifying information	3b
	The factor that affecting reaction rate	Making arguments	3c
Biofuel energy source	The factor that affecting reaction rate	Identifying information	4a
	The factor that affecting reaction rate	Analyzing information	4b
	The factor that affecting reaction rate	Connected Information	4c
	The factor that affecting reaction rate	Making arguments	4d
Medical use of alcohol	Order and law of reaction rate	Identifying information	5a
	Plot of rate vs concentration	Making arguments	5b

There were two items did not valid, and the RRCLT had a 0.78 Cronbach alpha coefficient. RRCLT was administered to students before and after the teaching intervention.

2.4. Data Analysis

Paired sample *t*-test analysis was used to see the effect of inquiry learning using local SSI context on students' chemical literacy before and after teaching intervention. Independent sample *t*-test analysis was done to compare chemical literacy in the

experimental and control class. After participating in inquiry learning using local SSI context for experimental class and scientific approach for control class, the enhancement of chemical literacy was obtained by calculating the average value of normalized gain (n-gain).

2.4.1 Hypothesis test for Paired Sample *t*-test

H_0 : there is no difference in students' chemical literacy ability for the pretest and post-test from both in the experimental class and in the control class

H_a : there is a difference in students' chemical literacy ability for the pretest and post-test from both in the experimental and control classes.

2.4.2 Hypothesis test for Independent Sample *t*-test

H_0 : there is no difference in students' chemical literacy ability between the experimental and control class

H_a : there is a difference in students' chemical literacy ability between the experimental and control class

3. RESULTS AND DISCUSSION

All data were normality distributed, and the paired sample *t*-test analysis result of the students' chemical literacy is presented in Table 2.

Table 2. The result of a paired sample *t*-test

Class	t value	df	Sig (2-tailed)
Pretest - Posttest Experimental Class	-23.376	31	0.000
Pretest - Posttest Control Class	-16.670	33	0.000

Based on Table 2, the results of the paired sample *t*-test analysis are known to be sig. (2- tailed) with the value is 0.000. This value is less than 0.05; it can be concluded that there is a difference in students' chemical literacy ability for the pretest and post-test from both in the experimental class and in the control class. Inquiry learning using local SSI can allow students to engage in argumentation, reasoning, and decision-making related to social problems related to science [21-22]. As a discussion material for chemistry concepts through real-life experiences, the local SSI context can be carried out by conducting inquiry activities because it has an important role in

increasing students' chemical literacy levels [3, 23]. So it can be concluded that there is an effect of inquiry learning using local SSI as a context on students' chemical literacy.

Table 3. The result of the independent sample *t*-test

	t value	df	Sig (2-tailed)
n-gain score (experimental and control class)	-3.817	64	0.000
	-3.828	63.919	0.000

Based on Table 3, the results of the independent sample *t*-test analysis are known to be sig. (2- tailed) with the value is 0.000. This value is less than 0.05, so it can be concluded that there is a difference in students' chemical literacy ability between the experimental and control class. Students in the experimental class were taught using context showed better chemical literacy ability than the control class [3].

Improvement of students' chemical literacy ability on each topic has been carried out by calculating the n-gain values evenly on each topic score on the reaction rate chemical literacy test (RRCLT), which is presented in Figure 1.

On the topic of coral reefs, enhancing students' chemical literacy ability in the experimental class was higher than in the control class. The increase in chemical literacy in the experimental class was 0.22. Meanwhile, the control class was 0.10. Based on the results on topic 1, most students had achieved content knowledge, chemistry in context, and HOLS. The item set was developed from a bomb explosion in fishing in Makassar, Indonesia 2019. Students are required to relate the collision theory based on the coral reef context described in the questions. This local SSI topic was answered by most of the students correctly. The experimental class students had greater improvement than the control group students in transferring their knowledge of reaction rates to the real-life context of coral reefs; the experimental class was better in utilizing their chemistry knowledge to explain everyday phenomena. Students used the concept of reaction rate to everyday life, and they could transfer knowledge about collision theory. Most students answered questions well by linked information. The research of [24] supported it; student's experience had a significant increase in content knowledge after being taught using the SSI context.

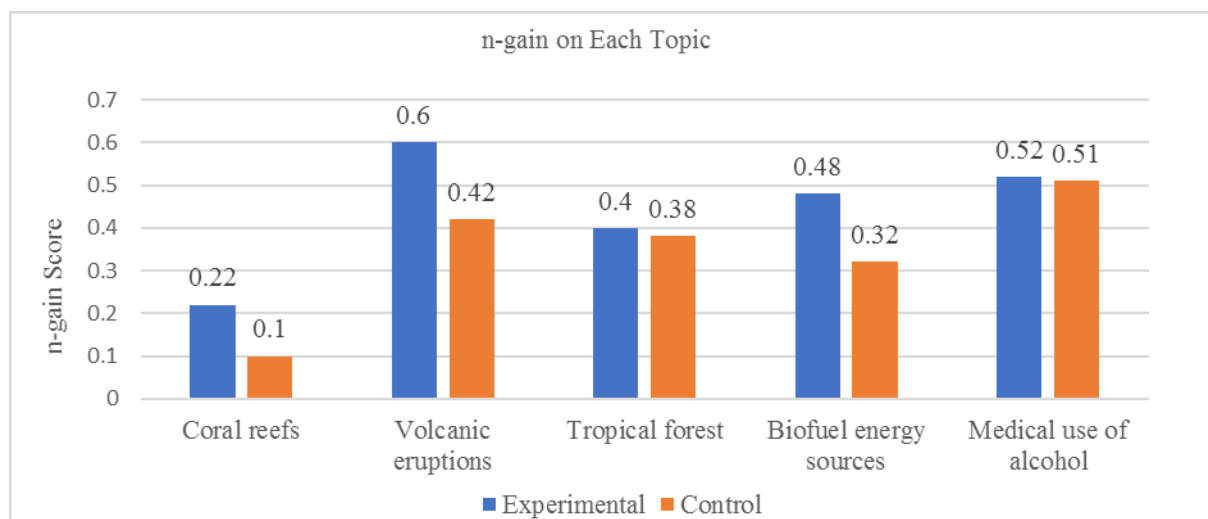


Figure 1. Enhancement of students' chemical literacy on each topic

Furthermore, the increase in student's chemical literacy on the second topic for the experimental class has a value i.e. 0.60, which was higher than the control class, i.e. 0.42. This topic discussed the problem of volcanic eruptions associated with the law of reaction rates. This topic was based on the content of knowledge, namely dynamic processes and reactions, chemistry in context (understanding chemistry in everyday life, and engage in social arguments on issues related to chemistry). Students were asked to write down the reaction of acid rain due to SO_2 gas released from Mount Merapi's eruption, and then students wrote down the reduction and formation rate. Almost all students wrote down the acid rain reaction correctly. Students were also asked to provide arguments about community involvement in Mount Merapi disaster mitigation on this topic. Some students in the experimental class had given correct arguments even though some students were still confused about writing their arguments. The effect of learning using the SSI context attracted students' interest and improved student argumentation, which was significantly higher than in the students involved. However, students still had difficulty developed their argument structure [25,13].

Based on Figure 1, it can be seen the increase in student's chemical literacy ability for topic 3 in the experimental class was 0.40, while in the control class, it was 0.38. This topic discussed forest fires and ecological impacts contained chemical knowledge content, chemistry in context, and high order learning skills (HOLS). Students were asked to write down the reaction caused by gas from forest burning related to the substance's a reduction and formation rate. For example, SO_2 gas reacted with water and oxygen caused acid rain. Most of the

experimental class students were able to write down the reactions then wrote in the form of the rate formula, in contrast to the control class, where only a few students could write only their chemical reactions. The forest fire context in chemistry learning could make students understand the reaction rate concept from the side of writing reactions based on the law of reaction rates. Indonesia's forest fires problem was an appropriate context, perhaps because the news of forest fires in Indonesia was broadcast on television media, students showed a high interest in chemical issues [1].

Based on Figure 1, students' chemical literacy ability in the experimental group had higher increased than the control group in transferring knowledge of reaction rates to biofuels energy sources' real-life context. The n-gain on biofuel energy sources topic for the experimental class has a value of 0.48, while the control class was 0.32. This topic was about biofuel energy sources becoming polemic associated with forest fires caused by land-use changes to plant oil palm was processed as biodiesel energy. Students were asked to identify factors that accelerated the reaction in processing palm oil into biodiesel. As a result, students transferred their knowledge about the factors that affected the rate of reaction over texts about biofuels. The biodiesel topic can be used to examine the reaction rate concept, namely the catalyst used in the biodiesel manufacturing process [26]. Students were asked to write their opinions regarding certain agricultural commodities as a biodiesel raw material source, most students agreed, and some students disagreed. Students wrote their arguments, not giving reasons for these arguments. It was related to research [27, 18] regarding improving the quality of arguments when analyzing all students' reasoning

statements. Students claimed biofuels were beneficial to the environment and economics of biofuels. Some students also claimed biofuels harmed the environment but showed limited arguments that were not supported by providing reasons and difficulties associated with SSI problems [28].

The last topic was about the use of alcohol in drugs. Based on Figure 1, the increase in students' chemical literacy ability on this topic for the experimental class has a value of 0.52 while the control class was 0.51. This topic discussed alcohol use in liquid cough medicines, which became a polemic [29]. The context was related to the reaction order. However, the increase was not much compared to other topics. It was possible that the control class students who were taught to use a scientific approach also understood the reaction order material, thus contributed to the value of increasing students' chemical literacy ability on the last topic. Students easily explained the contextual items because they were more familiar, more interesting, and more relevant to individuals [30]. Overall, students' chemical literacy ability on each topic showed that the experimental class was higher than the control class.

4. CONCLUSION

The results of the study showed differences in students' chemical literacy abilities before and after inquiry learning with the application of the local SSI context, there were differences in students' chemical literacy abilities between the experimental class and the control class, as well as an increase in students' chemical literacy abilities. Students' chemical literacy ability on each topic for the experimental class was higher than the control class. In this learning application, the controversial local issues arise as the characteristic of SSI induced the students to be more actively discussing and debating to train their chemical literacy.

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