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The Influence of Guided Inquiry Learning in the Context of Socio-Scientific Issues (SSI) on Students' Chemistry Literacy and Environmental Awareness on Reaction Rate Material

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Abstract: This research aims to determine the influence of guided inquiry learning contextualized with SSI on students' chemistry literacy and environmental awareness. This research is a quasi-experimental research with a non-equivalent (pre-test and post-test) control-group design. This research was conducted at SMA N 111 Jakarta and SMA N 41 Jakarta. The research sample consisted of 132 eleventh-grade students. The sampling technique used was cluster random sampling. The instruments used in this study consisted of a chemistry literacy test and an environmental awareness questionnaire. The data analysis technique used is multivariate statistics, specifically employing the MANOVA test. The research findings indicate that there are significant differences in students' chemical literacy and environmental awareness when implementing the guided inquiry learning contextualized with SSI. Overall, the impact of guided inquiry learning contextualized with SSI provides an effective contribution of 24.4% to students' chemical literacy and environmental awareness.

Keywords: Chemistry Literacy; Environmental Awareness; Guided Inquiry; Reaction Rate; Socio-scientific Issues

Introduction

The learning process is one of the crucial factors in creating the quality of a nation's education and plays a role in enlightening society, thus shaping the characteristics of a society that are in line with the challenges of the 21st century. One of the necessities is to build a community that has scientific or chemistry literacy skills through the education process (Rahayu et al., 2018; Qamariyah et al., 2021; Sari & Wiyarsi, 2021) to shape a society to be more critical, analytical, and creative in ways that support the development of 21st-century skills (Wulandari, Sunyono, & Diawati, 2018; Wiyarsi, Prodjosantoso, & Nugraheni, 2021). However, the reality is that students' chemical literacy skills in Indonesia are still considered very low.

Based on data from (OECD, 2016) in 2015 and (OECD, 2019) in 2018, the scientific literacy abilities of Indonesian students ranked among the bottom 10 countries out of a total of 72 countries. This indicates that the scientific literacy abilities of Indonesian students are still lagging behind those of the overall countries included in the Organisation for Economic Co-operation and Development (OECD). The chemistry literacy skills of students are still relatively low and therefore need to be improved (Dewi et al., 2019; Eny & Wiyarsi, 2019; Yustin & Wiyarsi, 2019). Possible factors contributing to the low level of chemistry literacy among Indonesian students include the gap between the chemistry concepts taught in schools and the real-life situations of students (Fibonacci, Haryani, & Sudarmin, 2017; Rahayu, 2017; Redhana et al., 2018; Tantu, 2018). This is because contextual learning in chemistry education is not emphasized enough, and the teaching approaches used are not linked to social issues in daily life (Rahayu et al., 2018; Tantu, 2018; Dewi et al., 2019).

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According to Shwartz, Ben-Zvi, & Hofstein (2006a, 2006b), there are four aspects of chemistry literacy skills that students should possess, knowledge of science & chemistry content, chemistry in context, High Order Learning Skills (HOLS), and afective aspects. Chemistry literacy refers to an individual's ability to understand and apply chemical knowledge based on everyday phenomena (Nada & Sari, 2021). Therefore, it is important to enhance the quality of learning that clearly integrates the necessary aspects to improve chemical literacy skills and utilize social issues as a bridge between chemistry concepts and students' real-life experiences, one of them is through the implementation of chemistry learning integrated with Socio-Scientific Issues (SSI).

SSI can enhance students' chemistry literacy abilities by providing a broader context to encourage students to explore science in the classroom. Using SSI as a context in chemistry education can make chemistry learning more relevant for students and can guide student learning outcomes (Sadler & Zeidler, 2004; Rahayu, 2017). However, in reality, teachers are not very familiar with the term SSI theoretically in the field of education, although they have implemented SSI in the learning process. A total of 64.6% of teachers have never or rarely implemented SSI in the learning process, 25.3% occasionally apply it, only 10.1% of teachers stated that they regularly implement SSI in the learning process, and no teachers claimed to have used SSI learning entirely (Nida et al., 2020).

One of the controversial topics of SSI is environmental issues. SSI topics directly related to environmental issues include greenhouse effect, global warming, air pollution, energy conservation, natural resources, and environmental conservation (Sadler & Donnelly, 2006; Fibonacci, Haryani, & Sudarmin, 2017; Qamariyah et al., 2021; Sari & Wiyarsi, 2021; Sulistina et al., 2021; Susilawati et al., 2021; Wiyarsi, Prodjosantoso, & Nugraheni, 2021). Environmental issues are closely related to students' environmental awareness. In line with Nida et al. (2020), one aspect of character formation or attitudes that can potentially be supported by SSI learning is environmental awareness. The issues presented in SSI are controversial, but contain additional elements that require a level of moral reasoning or ethical evaluation in the decision-making process for potential solutions (Zeidler & Nichols, 2009). SSI serves as one of the contextual learning approaches that can be applied in environmental education (Khoiri et al., 2021).

Environmental awareness plays a crucial role in education as it fosters students' dedication to preserving Earth and ensuring its sustainability for future generations, thereby creating a healthier and more habitable planet (Kousar et al., 2022). However, research by Adriyanto et al. (2021) shows that students' environmental awareness is not optimal in terms of behavior, indicating a need for improvement. In addition, there are still several environmental issues in the DKI Jakarta area caused by various human activities, such as the high level of air pollution. Therefore, it is necessary to enhance and still provide information related to environmental issues conveyed in the learning process (Sulistina et al., 2021), as a first step in reducing the risk of environmental damage in the future caused by human activities.

Utilizing environmental issues is highly suitable for assessing students' environmental awareness (Sulistina et al., 2021; Susilawati et al., 2021) and enhancing students' chemical literacy (Sari & Wiyarsi, 2021; Wiyarsi et al., 2021) through SSI contextual learning. The contextual SSI approach using environmental issues can be combined with a learning model that enhances active student engagement, one of which is guided inquiry. The guided inquiry learning process enables students to discover, decide, and utilize various sources of information and ideas to enhance their understanding of an issue (Kaltakci & Oktay, 2011). Guided inquiry learning can be implemented by incorporating contextual learning as a starting point to develop students' scientific thinking (Qureshi et al., 2017) and improve students' chemical literacy (Wardani & Anggraeni, 2020).

Integrating the SSI context into guided inquiry learning should be expanded with relevant chemistry topics (Wiyarsi et al., 2021). Reaction rates are one of the chemistry topics closely related to students' lives and contain many SSI contexts related to environmental issues. Some of these contexts include ocean acidification, global warming, greenhouse effect and so on (Fadly et al., 2022). Students with good chemistry literacy skills are expected to be able to apply their understanding of chemistry concepts to solve environmental problems and raise environmental awareness. However, guided inquiry learning integrated with contextual SSI about environmental issues on reaction rates is not widely known and applied by teachers.

Based on the issues described above, this research aims to investigate the influence of implementing the guided inquiry learning integrated with contextual SSI on students' chemical literacy skills and environmental awareness.

Method

The approach used in this research is quantitative. The type of research employed is a quasi-experiment with a non-equivalent (pre-test and post-test) control-group design (Creswell, 2012). The details of this research can be seen in Table 1.

Tabel 1. Research Design: A Non-Equivalent (Pre-test and Post-test) Control-Group Design

Pre-test	Treatment	Post-test
Y_1	X_1	Y_2
Y_3	X_2	Y_4

Information:
X_1 : guided inquiry learning contextualized with SSI for experimental group
X_2 : scientific approach for control group
Y_1: experimental group before treatment
Y_2: experimental group after treatment
Y_3: control group before treatment
Y_4: control group after treatment

This research was conducted at SMA N 111 Jakarta and SMAN N 41 Jakarta. The sampling technique used random sampling on four groups with a total of 132 students. This research consists of two experimental groups and two control groups. The experimental groups apply guided inquiry learning contextualized with SSI, while the control groups apply learning using a scientific approach. The instruments used in this study consist of essay questions on chemistry literacy to measure students' chemistry literacy skills and a questionnaire on students' environmental awareness to measure students' environmental awareness attitudes. Data analysis technique in this study uses Multivariate Analysis of Variance (MANOVA).

The pre-test and post-test scores were converted into Normalized Gain (N-gain) values to determine whether there was an increase in students' chemical literacy skills and environmental awareness after the learning process. The assessment scale for N-gain value outcomes can be seen in Table 2. According to (Hake, 1998), the N-gain value can be calculated using the following formula:

$$\text{N-gain} = \frac{\text{post-test score} - \text{pre-test score}}{\text{maximum score} - \text{pre-test score}} \quad (1)$$

Tabel 2. N-Gain Criteria

Large N-Gain	Criteria
<g> ≥ 0.7	High
0.7 > <g> ≥ 0.3	Medium
<g> < 0.3	Low

Result and Discussion

The Prerequisite Assumption Test Results for MANOVA

According to Stevens (2009), Hair et al. (2014), and Pituch & Stevens (2016), there are several steps in testing the assumptions of MANOVA. The prerequisite assumption test for MANOVA that must be met is the test of normality using the Shapiro-Wilk test, with a significance value (Sig.) > 0.05, indicating that the data is normally distributed (see Tabel 3).

Tabel 3. Normality Test Result

Shapiro-Wilk Test	Sig.
Chemistry literacy (Control)	0.196
Chemistry literacy (Experiment)	0.623
Environmental awareness (Control)	0.228
Environmental awareness (Experiment)	0.809

Testing for homogeneity of variance-covariance matrices was carried out using Box's M test, with the criterion that the obtained Sig. value should be > 0.05, which means there is no difference in variance (see Tabel 4).

Tabel 4. Homogeneity of Variance-covariance Matrices Test Result

Box's M Test	F	df1	df2	Sig.
1.288	0.423	3	304200.00	0.737

The next prerequisite test is the linearity test, which can be observed from the Sig. value. If the Sig. value of Deviation from Linearity is greater than 0.05, it indicates a linear relationship between pairs of dependent variables with each group of independent variables (see Tabel 5).

Tabel 5. Linearity Test Result

Linearity Test	Sig.
Chemistry literacy (Exp)*Environmental awareness (Exp)	0.648
Chemistry literacy (Con)*Environmental awareness (Exp)	0.174
Chemistry literacy (Con)*Environmental awareness (Con)	0.425
Chemistry literacy (Exp)*Environmental awareness (Con)	0.428

There is no multicollinearity. Multicollinearity criteria are assessed based on the Variance Inflation Factor (VIF) and Tolerance values. If the obtained Tolerance value is > 0.01 and the VIF value is < 10, then there is no multicollinearity (see Tabel 6).

Tabel 6. Multicollinearity Test Result

Variable	Colliniearity Statistic	
	Tolerance	VIF
Chemistry literacy	0.831	1.203
Environmental awareness	0.831	1.203

The MANOVA Test Result

The MANOVA analysis findings suggest a significant difference in both students' chemistry literacy skills and environmental awareness simultaneously between those who applied guided inquiry learning contextualized with SSI (experimental group) and those who applied the scientific approach (control group). The Sig. value of Hotelling's Trace is 0.000, which is less than 0.05, and the Sig. value of Roy's Largest Root is 0.000, also less than 0.05, indicating that H_0 is rejected (see Tabel 7).

Tabel 7. MANOVA Test Result

Effect	Value	Sig.	Partial Eta Squared	Information
Hotelling's Trace	0.323	0.000	0.244	There are significant differences and effects
Roy's Largest Root	0.323	0.000	0.244	

The result of partial eta squared indicates that guided inquiry learning contextualized with SSI has an effective contribution of 0.244 or 24.4%. The effective contribution has a significant influence based on criteria Richardson (2011), where the partial eta squared value obtained is greater than the value of $\eta^2 = 0.1379$, while the remaining 75.6% is influenced by other unknown factors.

The N-Gain Analysis Result

According to the N-Gain analysis findings, it shows that there are different outcomes in chemistry literacy skills and environmental awareness between the experimental and control groups (see Figure 1 & 2).

Based on Figure 1, the overall profile of chemistry literacy based on the average N-gain values shows that the N-gain value in the control group is 0.2618, which falls within the low criterion, whereas in the experimental group, it is 0.3728, categorizing within the moderate criterion. Therefore, the chemistry literacy abilities of students in the experimental group are better compared to those of students in the control group.

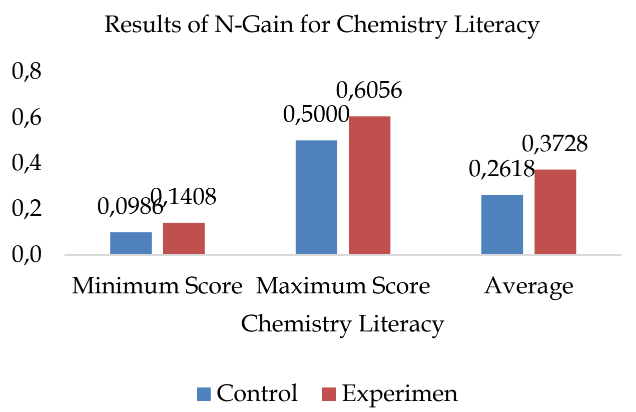

Figure 1. N-Gain of Chemistry Literacy Skills

According to Figure 2, the overall environmental awareness profile, based on the average N-gain values, indicates that the N-gain value in the control group is 0.3060, falling within the moderate criteria. Similarly, the N-gain value in the experimental group is 0.3699, also falling within the moderate criteria. Therefore, the environmental awareness of students in the experimental group are better compared to those of students in the control group.

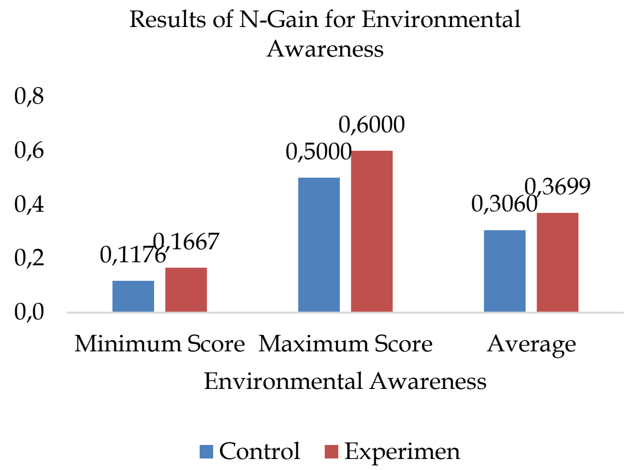

Figure 2. N-Gain of Environmental Awareness

Analysis of the Effect of Guided Inquiry Learning in the Context of SSI on Students' Chemistry Literacy and Environmental Awareness

The results of this study indicate that students in the experimental group have better literacy skills in chemistry and environmental awareness compared to the control group based on MANOVA analysis and N-Gain values. This is attributed to the different treatments provided in each group.

Guided inquiry learning contextualized with SSI can enhance students' literacy skills in chemistry by encouraging them to actively engage in discussions, argumentation, and reasoning related to environmental issues in real-life contexts (Sari & Wiyarsi, 2021). Additionally, in line with Sulistina et al. (2021), guided inquiry learning contextualized with SSI can also improve students' environmental awareness by connecting their chemistry knowledge to environmental issues in daily life, thereby fostering students' willingness to take action regarding environmental problems (Susilawati et al., 2021). The same opportunity is also provided for the implementation of the scientific approach, where students are encouraged to actively engage in discussions to build conceptual knowledge in chemistry.

The implementation of guided inquiry learning within the context of SSI can enhance students' chemistry literacy skills and environmental awareness. The utilization of SSI with environmental issues can improve students' scientific literacy and environmental awareness because the presented environmental problems can stimulate critical thinking skills and environmental awareness among students, enabling them to solve problems and seek solutions (Hanifha et al., 2023). According to Wardani & Anggraeni (2020), the implementation of contextual-based guided inquiry learning can enhance students' chemistry literacy skills because this teaching model facilitates and guides students to connect the chemistry knowledge gained in the classroom with real-life contexts, making the learning more meaningful. Additionally, this teaching model can cultivate students' environmental awareness (Wardani & Anggraeni, 2020) because students' environmental consciousness is closely related to their own life sustainability (Naezak, Savitri, & Fibriana, 2021). In line with Sholahuddin et al. (2020), guided inquiry learning with environmental learning resources is effective in improving students' chemistry literacy skills because this teaching model can optimally engage students in learning through scientific method steps and facilitate more meaningful learning. Students with good chemistry literacy not only understand the material conceptually but also can use their knowledge to explain phenomena scientifically and solve problems, including environmental issues. Additionally, consistent with Muhlisin et al. (2019), guided inquiry learning within the context of environmental issues can enhance students' environmental awareness because students become more active in problem-solving through discussions and presentations, thereby encouraging students to interact with the environment, observe environmental issues, and form environmental behaviors.

The stages of guided inquiry learning within the context of SSI allow students to be more active in learning and encourage them to find answers to a problem step by step, starting from problem orientation to drawing conclusions under the guidance of the teacher. There are four discourses related to the concept of reaction rate: 1) vehicles over 10 years old are prohibited from operating in Jakarta; 2) coral reef ecosystems are damaged due to ocean acidification and global warming; 3) catalytic converters as an alternative solution to reduce harmful exhaust emissions from vehicles; and 4) global warming (ozone layer depletion).

Here are some points about the influence of guided inquiry learning contextualized with SSI on students' chemistry literacy and environmental awareness. First, the discourse on environmental issues provided during the problem orientation stage appears to be effective in enhancing students' chemistry literacy aspects and serves as a bridge between chemistry concepts and real-life situations for students (Fibonacci, Haryani, & Sudarmin, 2017). The use of SSI in classroom learning activities is an initial step towards developing science literacy (Zeidler, Herman, & Sadler, 2019). Additionally, this serves as a crucial initial step for students to build a conceptual understanding of the chemistry being studied and to comprehend chemistry contextually for use in developing students' environmental awareness. Considering that environmental awareness is directly related to changes in students' knowledge or perceptions, which are prerequisites for behavioral changes and actions towards the environment, the delivery and consideration of moral/ethical aspects become necessary in the context of SSI. This proves to be a good strategy for enhancing students' environmental awareness (Hadzigeorgiou & Skoumios, 2013).

Secondly, the problem formulation stage provides students with the opportunity to reason and identify environmental phenomena based on the discourse presented, which are then connected to the topic of reaction rates. It is not easy for students to link chemistry concepts with environmental phenomena, thus the role of the teacher is crucial in guiding the formulation of problem questions to elucidate the context and concepts of reaction rates as the foundation that students need to know in order to build concepts. As an example, students can formulate problems in the form of questions such as: "How is the reaction rate of gasoline combustion in motor vehicles? Does it occur rapidly or slowly?"; "Why do some reaction rates occur quickly while others are slow? Is there a connection to collision theory?"; "How is the reaction rate of ocean acidification affected if CO_2 emissions increase on Earth? What are the impacts on coral reef ecosystems?". Based on this problem formulation stage, it can encourage students to enhance their reasoning, argumentation, and scientific thinking to proceed to the hypothesis formulation stage, where students provide answers or temporary conjectures related to the questions that have been posed.

Thirdly, the data collection stage provides students with the opportunity to actively engage and conduct investigations using various learning resources to develop students' literacy skills in chemistry and environmental awareness. Students collect data by searching for various relevant information sources related to the rate of reaction material and the environmental issue phenomena presented through books, articles, mass media, or other sources. Students also engage in group discussions and design simple laboratory experiments to construct their knowledge independently. In the data collection stage, there are also questions related to solutions and impacts related to environmental issues. Students are guided to have knowledge and attitudes of environmental awareness, as well as scientific arguments in solving environmental problems. The application of argumentation in learning is one important aspect to support and assist students in explaining environmental issue phenomena (Sadler & Donnelly, 2006; Salsabila Wijaya, & Winarno, 2019), thus students know what steps to take to solve environmental problems.

During the above learning process, the role of the teacher is to guide students in decision-making and verify the outcomes of their decisions to ensure clarity in the teaching content. This stage can have a positive and significant impact on learning activities, investigations, performance success, and student learning outcomes (Zhang & Cobern, 2021; Khairi & Ikhsan, 2022).

Conclusion

Based on the research results, it can be concluded that there is a significant influence of guided inquiry learning contextualized in SSI on the topic of reaction rates towards students' chemical literacy and environmental awareness. The effective contribution of this learning model is 24.4%.

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All authors contributed to writing this article. Author contribution, validation, data curation, formal analysis, writing – original draft preparation, review and editing, M.H.; resources, M.H and S.H.; supervision, S.H.

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Conflicts of Interest

The authors declare no conflict of interest.

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