The Influence of Guided Inquiry-Based Learning Using Socio-Scientific Issues on Environmental Awareness of Pre-service Chemistry Teachers

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ABSTRACT

The present study investigated the influence of guided inquiry-based learning using socio-scientific issues related to environment on the environmental awareness of pre-service chemistry teachers in the fundamental chemistry class. The study was designed according to the triangulated mixed-method design. The participants were 44 pre-service chemistry teachers. Data was collected using the Environmental awareness questionnaire (EAQ) and environmental awareness interview guidelines (EAIG). The quantitative data were analysed with the SPSS program package by using descriptive statistics, paired sample t-test, and normalized gain ($<g>$). The qualitative data were analysed qualitatively. The result of the analyses shows that guided inquiry-based learning using socio-scientific issues related to environment increased students' environmental awareness. The highest score was achieved in the environment optimism aspect.

Keywords: *Socio-scientific issues, Guided inquiry-based learning, Environmental awareness, Chemistry.*

1. INTRODUCTION

Environmental issues became a global issue in the 21st Century and a challenge for all parties to be involved in solving these issues. Examples of environmental issues that are often discussed include the increase in greenhouse gases in the atmosphere [1], and human deaths due to air pollution [2]. The cause of these issues is the human activity that does not pay attention to sustainability. Increased greenhouse gases and air pollution are caused by industrial activities, transportation, or excessive logging, causing disturbed natural balance. Events like this require humans to have environmental awareness for sustainability to occur because their awareness plays a vital role in maintaining the balance and preservation of nature [3]. Humans and nature are interdependent [4], [5]. Therefore, promoting environmental awareness is an essential goal in education [6].

Environmental awareness is a combination of motivation, knowledge and skills possessed by someone [7]. This variable is directly related to environmental knowledge, attitudes, and actions [8], [9], or knowledge that can influence one's attitude

[10]. The definition implies that people who have high environmental awareness will use their knowledge in taking attitudes and actions that pay attention to the environmental balance and sustainability. Three indicators can measure the level of environmental awareness of students, namely awareness of environmental issues, perception of environmental issues, and environment optimism [11]. Environmental awareness of students needs to be improved. The PISA 2015 results show that only 19% of students can be aware of environmental issues and understand the complexity of these issues [11]. Students gain experience of environmental awareness through mass media, both audio and print, but participation in school activities related to environmental awareness is still low [12].

Chemical education is considered to have a central role in education for sustainable development (ESD) [13], [14]. ESD empowers individuals to make decisions and actions responsibly for the environment, economic viability and just society for present and future generations [15]. Referring to one of the ESD objectives related to the environment, therefore developing students' environmental awareness is also a goal of chemical education.

Science education has a vital role in developing an principles that underlie issues related to the environment [9]. The science curriculum offers many opportunities to support environmental awareness [16], [17].

One of the roles of the teacher is to help students form views about the world, economic potential, attitudes towards others in society, participation in community decision making, and interactions with the environment [18]. These facts show the vital role of teachers in instilling environmental awareness in their students. The teacher is a crucial factor for the potential success of any educational reform [19], [20]. Effective education reform will only occur when the initial knowledge, attitudes and beliefs of teachers are taken seriously [21], [22]. Based on this description, increasing the environmental awareness of pre-service chemistry teacher is very important to do.

Efforts to develop environmental awareness through science education are carried out implicitly or explicitly in the curriculum. Science learning that makes explicit the relationship among students, science and nature can be meaningful to students [23] and helps integrate science concepts with real-life experiences related to environmental consequences [9]. As part of science, chemistry has unique characteristics, which is developed based on the processes and products of scientists. Based on these characteristics, appropriate learning is inquiry-based learning. The goal of inquiry-based learning is to encourage students to develop knowledge about science (scientific concepts and the nature of science), scientific skills and attitudes (curiosity, critical, problem-solving, science process skills, scientific explanation and scientific argumentation) [24]. The characteristics of inquiry-based learning may not promote environmental awareness because it is more focused on science itself [23]. Therefore, it is necessary to integrate learning about the environment through inquiry-based learning using environmental issues. Environmental issues presented in the context of socio-scientific issues (SSI) will make student learning more meaningful in efforts to develop their environmental awareness [9], [23]. SSI can help students find the relevance of science to social and personal problems so that the ability to make decisions will increase [25], [26]. Based on this description, inquiry-based learning using socio-scientific issues related environment is possible to increase the environmental awareness of students, especially the environmental awareness of pre-service chemistry teachers. The research objectives

understanding of scientific are (1) to determine the effect of guided inquiry learning strategies using socio-scientific issues related environment to the environmental awareness of pre-service chemistry teachers, and (2) to describe the environmental awareness of pre-service chemistry teacher before and after learning with guided inquiry strategy using socio-scientific issues related to the environment.

2. METHOD

2.1. Study group

This study used a triangulated mixed-methods design to determine the effect of guided inquiry learning by using socio-scientific issues related to the environment in increasing the environmental awareness of pre-service chemistry teachers. The purpose of using the design was so that researchers can use quantitative and qualitative methods to study the same phenomenon to determine whether they produce similar answers to the research problem being investigated [27]. Quantitative methods were carried out using a one-group pre-test-post-test design. The study was conducted at one of the state universities in Malang, with 44 members in a group of pre-service chemistry teachers attending the Basic Chemistry course. After treatment, the pre-test and post-test data results from filling out the environmental awareness questionnaire were collected, then the data were analyzed using quantitative analysis techniques. Qualitative data in the form of data from interviews after learning is collected and documented in audio recordings and analyzed with qualitative analysis techniques. Interview data were obtained from 10 students chosen voluntarily. Quantitative data and qualitative data obtained were analyzed separately, and then the results are combined and interpreted to get a more detailed and accurate picture.

2.2. Intervention

The intervention was carried out by providing guided inquiry learning using socio-scientific issues related environment. The stages of guided inquiry-based learning using environmental issues include the orientation phase, the conceptualization stage, the inquiry, the discussion stage, and the concept application stage. The first four stages help students build knowledge about chemical content, and the last stage, application of concepts, is used to develop students' environmental awareness. In the application

stage, the concept is presented an article which contains environmental issues in the context of SSI. Learning is done for seven (7) times face-to-face (@ 150 minutes).

The issue is presented in the form of articles (reading material about the benefits of these materials for human life and the dangers for the environment) after students read and understand the article students are asked to argue about the usefulness of the product, problems that might result from the product, and their attitudes related to usability and problems that might be caused to the environment from the use of these products and how their role (both ideas and behaviour) can help anticipate or reduce these problems. This intervention aims to determine the effect of inquiry learning using environmental issues in increasing environmental awareness of students. The example is an issue of using instant disposable cold packs that apply the concept of exothermic reactions to the learning of thermochemical material. The issue presented is about the benefits and risks of using cold packs on health and the dangers of disposable cold pack waste on the environment.

2.3. Research Instrument

The research instruments were used environmental awareness questionnaire (EAQ) and environmental awareness interview guidelines (EAIG). EAQ measures three aspects of environmental awareness, namely awareness of environmental issues, perception of environmental issues, and environment optimism which is a modification of the 2015 PISA survey questionnaire. Interviews were conducted to sharpen the findings. Interviews were conducted with semi-structured. The EAQ and EAIG instruments have valid content validity. All EAQ items are valid and reliable. The reliability items on the aspect of awareness of environmental problems are very high (r = 0.824), on the item aspect of the perception of environmental problems is high (r = 0.653), and on the item aspect of environmental optimism is sufficient (r = 0.541). To increase the validity of the results, quantitative and qualitative data are triangulated.

Quantitative data were obtained from EAQ measurements with a Likert scale (5 scales), to determine the level of environmental awareness of students. The criteria for environmental awareness level are as follows: 1 (very low); 2 (low); 3 (medium); 4 (high); 5 (very high). Student quantitative answers were analyzed by SPPS using paired sample t-test. The hypothesis tested in this study is H0 and Ha. H0 means there is no significant average difference between pre-test and posttest environmental awareness, which means there is no

influence on the use of guided-inquiry learning strategies using socio-scientific issues related environment in increasing students' environmental awareness. Meanwhile, Ha means there is a significant average difference between pre-test and posttest environmental awareness, which means there is an influence on the use of guided-inquiry learning strategies using socio-scientific issues related environment in increasing students' environmental awareness ". The test decision results are taken with the guidelines, if the value of sig (2-tailed) <0.05, then H0 is rejected and Ha is accepted [28]. To find out the magnitude of the effect or effectiveness of the learning strategy analysis <g>, with the criteria "high-g" with (<g>) ≥ 0.7, "medium-g" with 0.3 "(<g>)> 0.7, and" low -g ", (<g>) <0.3 [29], [30]. Qualitative data were obtained from the results of semi-structured interviews. The stages of data analyzed qualitative are data reduction, data presentation then concluding.

3. RESULT AND DISCUSSION

3.1. The influence of guided inquiry learning strategies using environmental issues on the environmental awareness of prospective chemistry teacher students

Data on students' environmental awareness were obtained from pretest and posttest grades. The data obtained have normal variants (sig. Kolmogorov-Smirnov test for pretest and posttest data of 0.200 > 0.050) and homogeneous (sig. Levene test sig value of 0.200 > 0.050). Paired t-test results are presented in Table 1 and Table 2. The test results show that: (1) the average level of environmental awareness of students before learning is 3.33, and the standard deviation is 0.321 and after learning is 3.79 and the standard deviation is 0.279. It means that descriptively there are differences in the average level of environmental awareness of students before and after learning with inquiry strategies using environmental issues; (2) there is a significant difference in the level of environmental awareness of students between before and after learning (sig. (2-tailed value) of 0,000 < 0.050). Based on the test results, it can be concluded that the guided inquiry learning strategy using socio-scientific issues related to the environment affects the increase in environmental awareness of students. The <g> test results obtained <g> value of 0.26, which shows that the influence of guided inquiry strategy using socio-scientific issues related environmental to increase the students' environmental awareness in the low category.

Table 1. Descriptive statistic

	Mean	N	Std. Deviation	Std. Error Mean
Pre-test	3.33	44	0.321	0.048
Post-Test	3.79	44	0.279	0.042

Table 2. Paired sample t-test

	Mean	Std. Deviation	Std. Error Mean	df	Sig. (2-tailed)
Pre-test-Post-Test	-0.46	0.254	0.038	43	0.000

The low influence is due to students' initial environmental awareness ability correlated with their final ability. It can be explained from the results of paired samples correlation test with sig values. 0.000 < 0.050 as in Table 3. It is consistent with the results of several studies that students with high initial ability have high learning outcomes and students also own low learning outcomes with a low initial ability [31], [32], [33].

The orientation stage, the conceptualization stage, the inquiry, the discussion stage on the learning strategy used to build their understanding of the chemical content being studied, and the concept application stage are used to develop students' environmental awareness. Guided inquiry-based learning emphasizes active participation and the responsibility of students to build new knowledge for students [34]. The concept application stage provides experience for students to connect the chemical knowledge that has been obtained with environmental issues that occur due to the use of chemicals to develop student environmental awareness. Chemical knowledge is needed by the public to understand many problems that threaten the sustainability of our planet, such as the mechanism behind climate change and the potential side effects on our personal lives caused by the production of goods, the production of alternative energy [35], [36]. Therefore, chemistry education must emphasize students' understanding of the role of chemistry in society and enhance their ability to evaluate business and chemical-related products, such as how chemistry can affect the future, contribute to a sustainable society and help in the proper stewardship of natural resources [14].

3.2. Environmental awareness of prospective chemistry teacher students before and after learning with inquiry strategies using socio-scientific issues related environment

Environmental awareness is one aspect of attitude assessment at PISA. The environmental awareness assessment includes three indicators, namely (1) knowing and being aware of the surrounding environmental problems (Awareness of environmental issues), intended as a measurement of the capacity of students to understand and know the source of the surrounding environmental problems; (2) perception of environmental issues, described as the level of student concern for the surrounding environmental problems; (3) confidence in solving environmental problems and contributing to the sustainability of the environment (environment optimism) [11].

The level of environmental awareness of students has increased from before and after learning using guided inquiry strategies with SSI related environment. Figure 1 shows that the highest increase occurred in the aspect of environment optimism (EO) with an increasing point of 0.57, the aspect of the perception of environmental issues (PEI) of 0.51, and the lowest aspect of awareness of environmental

Table 3. Paired samples correlations

	Mean	correlation	Sig.
Pretest & Postest	44	0.650	0.000

issues (AEI) of 0.29. Students who have a high EO give an opinion on the question "is learning able to make you aware of contributing to environmental sustainability, especially to minimize the negative impacts of plastic use and fuel use?" as follows:

Ibn, Alf, Sol, Far, Fik, Sher, Mil, and Dhe. : "I have brought more items that can be used many times like I bring my own drink bottles, because before I often really buy disposable packaging drinks made of plastic. I previously used Pertalite, ma'am. However, since the time of the lesson, I tried to use Pertamax.".

Dim : "If you want to buy anything, you can only see whether it's disposable, polluting the environment or not, it's better to buy a little expensive but not polluting the environment. For example, shopping at market, I now bring my own bag, cloth bag. If not, I put the grocery items directly in my backpack. Even

though I did not pay 200, I still chose not to use plastic, Ma'am. Because environmental factors are also not good for the environment. When I want to buy gasoline, I use Pertamax and Pertalite, so the price can be half, and continue to make the environment pretty good compared to only Pertalite."

Fik : "Previously I used pertalite. After learning, I use Pertamax. I also try to explain to parents that using Pertamax has a better impact on the environment."

Sher and Mil : "I have used Pertamax, but after learning, I better understand that using Pertamax is more environmentally friendly."

Descriptions of environmental awareness before and after learning in each aspect are presented in Figure 2, Figure 3, and Figure 4. Figure 4 shows that after learning, 95% of students have EO at level 4, which initially only 55% of students have EO level 4. In the PEI aspect, students who reached level 5 increased from before learning only 7% to 27%, and those who reached level 4 from 64% to 73% (Figure 3). Figure 2 shows that after learning, students who reached level 4 were 27%, previously 20%. It indicates that knowledge and awareness of environmental issues and problems in the surrounding areas still need to be significantly improved. Education in schools becomes the leading media in providing information about environmental issues and forms attitudes and behaviours that are environmentally conscious [12]. Therefore, presenting environmental issues and making explicit the formation of students' environmental awareness in learning needs to be increased in frequency.
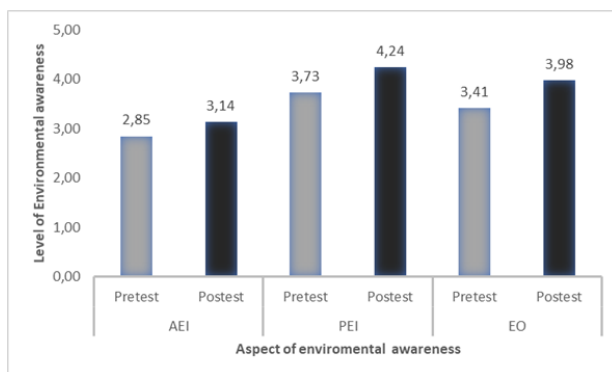

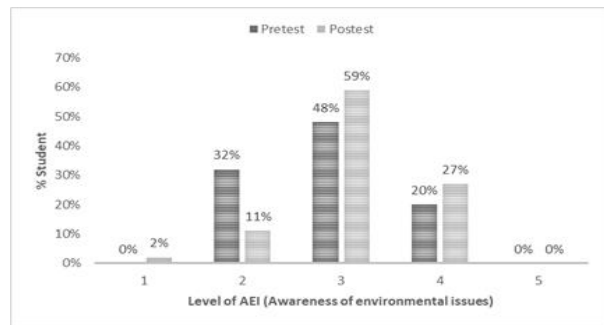**Figure 1** The level of students' environmental awareness in each aspect.

Figure 2 Level of students' awareness of environmental issues (AEI) before and after the intervention.
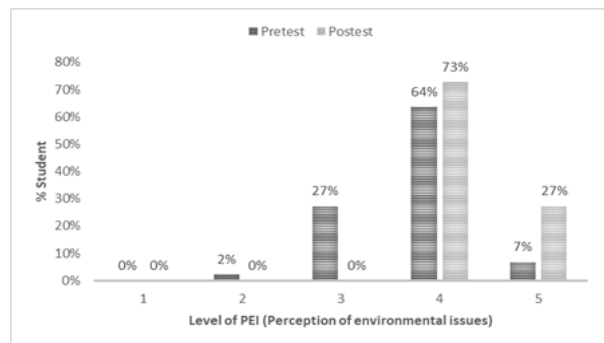

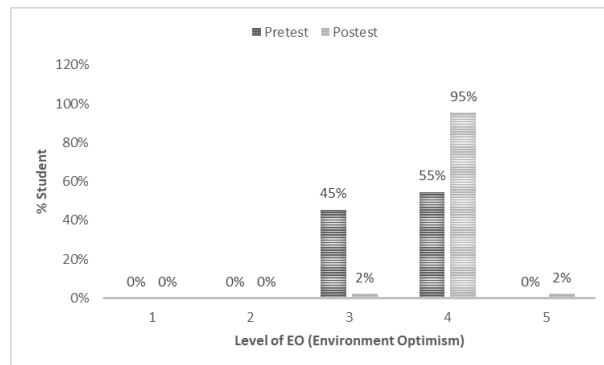**Figure 3** Level of students' perception of environmental issues (PEI) before and after the intervention.

Figure 4 Level of students' environment optimism (EO) before and after the intervention.

4. CONCLUSION

The results showed that the guided inquiry strategy using socio-scientific issues related environment had a significant influence in increasing the environmental awareness of pre-service chemistry teachers. However, the effect is still low. It is due to the initial environmental influence of students which is already quite high. Another factor that might have caused the low influence was that students were not accustomed to learning an inquiry strategy using

environmental issues. Therefore, it is necessary to apply the learning strategy to learning other topics or other relevant subjects. The finding supports this that the level of students' awareness of environmental issues is still low, which indicates that information is still needed relating to the issues of environmental problems presented in lectures. The level of environmental optimism and the perception of environmental issues of them were high indicate that pre-service chemistry teacher students well receive guided inquiry learning using socio-scientific issues related environmental. Based on this, it is probable that they will be moved to in still environmental awareness to their students through learning when they have entered the profession as in-service teachers.

AUTHORS' CONTRIBUTIONS

Oktavia Sulistina develop the concept and design the manuscript, Sri Rahayu provided key information and key intellectual support and helped revise the manuscript, I Wayan Dasna and Yahmin provided key intellectual support.

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