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Enhancing Students' Interpretation and Self-regulation Skills Through Socio-scientific Issues (SSI) Approach Related to Environmental Change Topic

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Abstract.

This study aimed to determine the effect of SSI learning on environmental change topics on students' interpretation (SIS) and self-regulated skills (SRS). The method used was pre-experiment with one group pre-test and post-test design. The participants in this study were 57 students in 7th grade (32 boys and 25 girls) chosen using a random sampling technique. The instrument was a test with 6 essay questions for interpretation and self-regulation. Research data were analyzed through prerequisite tests, paired sample t-tests, n-gain scores, multivariate analysis of variance (MANOVA) test, and Pearson correlation test. The results prove that SSI learning for these topics had no significant effect on students' interpretation skills and self-regulation. The n-gain score analysis also proves that only 0.34 for interpretation skills and 0.36 for self-regulated skills are in the moderate category. However, the cluster analysis shows differences in student SIS and SRS for low levels but not middle and high ones. Finally, the Pearson correlation test shows a positive relationship between students' interpretation and self-regulated skills.

Keywords: self-regulation skills, Socio-scientific Issues (SSI), environmental change

1. Introduction

Education is essential in preparing the quality of human resources for Indonesian people to compete in global competition [1–6]. The learning process, one of the main components of education, has several main principles. The first principle states that learning aims to develop student behavior. Furthermore, learning must be prepared based on needs and motivation. Then, learning is conducted by training, forming

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associations, and strengthening. Learning must also be comprehensive, emphasizing critical thinking skills and reorganizing experiences. In addition, learning requires direct guidance by the teacher or indirect guidance through experience. Finally, learning is influenced by factors from within and outside the individual [7–11]. The new principles of the learning process have proved that education is no longer centered on the teacher but tries to involve students as the main focus of learning.

The 21st-century skills require students who master information and technology skills, social and communication skills, problem-solving, cooperation, and critical thinking [1, 6, 12–18]. Learning that reflects 21st-century skills refers to students' activeness in analyzing and compiling their understanding based on their experience and knowledge, which is called higher-order thinking. One strategy for teaching higher-order thinking is contextual learning, which teaches material that is appropriate to real-world situations, and encourages students to relate their knowledge and its application in life as a family or community [11, 19, 20]. Thus, students gain knowledge from their efforts to construct new knowledge and skills when they learn.

Phenomena in society have problems and scientific integrity, so it requires a reasoning process in responding to these, i.e., the issue of environmental change that occurs in water, soil, air, and waste processing [21–23]. These problems cannot be separated from social issues, which raise environmental problems and social conflicts if not resolved through critical thinking. The thinking needed to solve this problem is a pattern of interpretation and proper self-regulation based on scientific facts from the problem, environment, and society.

Today's environmental problems have become a thorny problem in society [22, 24]. Environmental damage is characterized by a decreased quality of the environment's carrying capacity due to increased waste and incomplete handling. In addition, the abundance of domestic and industrial wastewater pollutes the aquatic environment contributing to the potential for more significant environmental damage. In the atmosphere, environmental damage comes from high air pollutant gas emissions. Finally, the changes in land use that result in the reduction or loss of germplasm and damage due to natural disasters significantly impact the quality of human life [25, 26].

Students' interpretation skills (SIS) help a student to understand something based on experience and knowledge. This ability is crucial to help students understand a phenomenon. SIS has a significant role in improving critical thinking skills. By having good interpretation skills, students will automatically be able to provide responses and perceptions of phenomena that are happening or that have already occurred[27, 28]. Besides, self-regulation skill (SRS) is essential to learn in a socio-scientific issue (SSI). SRS is the ability to control itself. In terms of addressing social issues in the context of science or addressing science issues during social life, students must be able to

place themselves, namely through self-regulation. The SRS is also a characteristic and indication for students who have critical thinking skills [29].

Studying issues/phenomena that occur in everyday life can be a strategy for practicing critical thinking skills by mastering the correct scientific concepts. Students are expected to have a scientific consideration framework not based on a mere emotional and intuitive basis [30, 31]. The critical factor for students to think critically is the relationship between concepts and actual events in everyday life. Critical thinking skills' ultimate goal is for students to harmonize the knowledge gained to solve everyday problems [32]. Learning strategies and the right approach are needed to make this happen. A potential learning approach to be applied is SSI which is applied with discovery-based multiple representation models.

The SSI learning approach can potentially support the development of intellectual abilities, communication skills, social attitudes, caring, and student participation. The SSI is an approach that aims to stimulate intellectual, moral, and ethical development as well as awareness of the relationship between science and social life [33, 34]. However, studies on SIS and SRS with the SSI approach are still not popularly discussed. Previous research explains that there are three great potentials for the study of SSI, namely 1) SSI and the Central Role of SS Reasoning; 2) SSI and the Primacy of SS Perspective Taking, and 3) SSI and the Importance of Informal and Place-Based Contexts. Therefore, the researchers took the initiative to fill the gap in SSI research, especially in learning physics. This study aims to determine the effect of SSI learning on environmental change topics on students' interpretation and self-regulated skills.

This study responds to the following research questions to achieve its specific objectives

1. Does SSI learning on environmental change topics affect student interpretation and self-regulated skills?
2. How effectively is using SSI learning on environmental change topics to improve student interpretation and self-regulation skills?

2. RESEARCH Method

2.1. Research Design

This study used a pre-experimental method with a pre-/posttest design as the experimental class using the SSI context (DL-SSI). Then, SIS and SRS were measured before and after the treatment.

2.2. Research Sample

The method was pre-experiment with one group pre-test and post-test design [35]. Fifty-seven students, 32 boys and 25 girls, in the 7th grade, were selected by random cluster sampling from one junior high school in Sleman, Indonesia. The same teacher taught classes with students with the same socio-economic background, an age range of 12–13-year-olds, and unequal prior knowledge about sciences with three categories of ability high, medium, and low. There are 9 students at the Low Level, 44 at the Middle level, and 7 at the High level. Moreover, in the SIS aspect, the distribution of students' abilities is that 36 students are in the low group, 16 are in the medium group, and 15 are in the high group. In the SRS aspect, there were 2 students in the low group, 50 in the medium group, and 15 in the high group.

2.3. Teaching Intervention

The intervention given to students in this study was divided into three stages. In the first level, students are given treatment to conduct discussions and listen to the teacher's explanation. The second level of treatment is done by directing students to work on a worksheet based on Discover Learning. At the next level, students are given treatment to create a concept map of the topics that have been discussed. Finally, at the treatment at the peak level, students were asked to make posters related to environmental conservation, especially those related to the Merapi sand mine as SSI in this study. The teacher's pattern of assistance in each treatment level is also stratified. The higher the level of treatment, the smaller the proportion of assistance provided by the teacher. Up to the fourth level in making posters, the teacher only gave instructions and explanations about the task without providing the slightest assistance and assistance.

2.4. Data Analysis Techniques

The data was collected using 3 essay questions on interpretation skills and 3 self-regulated students. Research data were analyzed through prerequisite tests [36], paired sample t-test [37], n-gain score [38], multivariate analysis of variance (MANOVA) test [39], and Pearson correlation test [39]. Multivariate Analysis of Variance (MANOVA) was used as the inferential statistic technique to analyze the differences among the groups in students' SIS and SRS. The prerequisite of the MANOVA has been calculated. The data have normal distribution based on the Shapiro-Wilk test with $p > 0.05$ for both SIS and SRS. The Levene test ($p > 0.25$) showed that the data are homogeneity and

the Box's M test indicated that the data do not have homogeneity of matrix variance-covariance (p = 0.036). It means that the Pillai Trace test of MANOVA is the appropriate one. The paired t-test was used to analyze the differences between pre-and post-data in the experimental and control classes.

3. Results and Discussion

The increase in students' abilities was shown by the Normalized-gain value of 0.34 in the "interpretation" aspect with moderate interpretation and 0.36 for the self-regulation aspect with moderate interpretation [40].

Table 1: Output t-test.

	t	Sig. (2-tailed)	Mean Difference
Interpretation	-4.864	.000	-0.82
Self-Regulation	-4.291	.000	-0.68

Table 1 shows the results of different tests where there are differences in every aspect of the pre-test and post-test results indicated by the significance value or p-value being smaller than 0.05. Overall, the difference was 0.82 for interpretation and 0.68 for self-regulation.

Table 2: Output Multivariate ANOVA (MANOVA).

Effect	Value	F	Sig.
Wilks' Lambda	.439	14.281	.000

Table 2 indicates a significant influence of SSI on students' interpretation and self-regulation abilities which is indicated by a significance value smaller than 0.05 in the four test systems. In the Wilks' Lambda test, there is an adjustment by the statistical results' upper bound on F, which yields a lower bound on the significance level [42].

Table 3: Tests of Between-Subjects Effects.

Source	Dependent Variable	Mean Square	F	Sig.
Intercept	Interpretation	125718.07	171.417	.000
	Self-Regulation	180312.79	361.273	.000
Cluster	Interpretation	1238.53	1.689	.194
	Self-Regulation	416.16	.834	.440

The significance value at the intercept is less than 0.05, meaning there is a difference in pre and post-test by ignoring the treatment. [39]. However, the source cluster shows more detailed results with a significance value in the Interpretation aspect of 0.194 > 0.05, which means that SSI has no significant effect on this aspect. The same results in

the self-regulation aspect also show that SSI does not have a significant effect, with a significance value of 0.440> 0.05. The other test results in Table 4 are the R squared value for SSI-Interpretation and self-regulation correlation, respectively 0.56 and 0.28, which are still low (the correlation is stronger if R 1) [41].

Table 4: Multiple Comparison.

Dependent Variable	(I) Cluster	(J) Cluster	Mean Difference (I-J)	Std. Error	Sig.
Interpretation	Low	Mid	-41.7298*	7.99086	.000
		High	-60.3175*	11.00760	.000
	Mid	Low	41.7298*	7.99086	.000
		High	-18.5877	8.88818	.123
	High	Low	60.3175*	11.00760	.000
		Mid	18.5877	8.88818	.123
Self-Regulation	Low	Mid	-26.4520*	6.89212	.001
		High	-46.8254*	9.49407	.000
	Mid	Low	26.4520*	6.89212	.001
		High	-20.3734*	7.66606	.031
	High	Low	46.8254*	9.49407	.000
		Mid	20.3734	7.91721	.078

Next is the analysis of the difference between groups of improvement (Low-Mid-High). There is an indication of a significant difference or asterisk (*) in the Different Mean column, and the significance value is less than 0.05 [42]. Table 5 shows that, in general, a significant difference is between the Low-Mid and Low-High groups. However, the Mid-High group had almost the same or no significant difference [43].

3.1. The Effects Before and After the Implementation of Discovery Learning Using the SSI Context Toward Students' SIS

The results showed no significant effect on improving students' SIS after participating in learning using the DL-SSI. These findings provide relatively different results from other studies, especially in the use of Discovery learning (DL). In fact, in previous research reports, it was stated that DL could improve Mathematical ability, which is very similar to the interpretation process [44]. On the other hand, many studies have reported that DL can significantly improve critical thinking skills, and SIS is also part of the Critical thinking indicator [45, 46].

However, the advanced analysis considered the students' abilities (high-medium-low). This analysis proves that there are only two different clusters, that is, between the high

and low clusters and the medium and low clusters. Meanwhile, in the high and medium clusters, the average score was relatively the same, and it was stated that there was no significant difference.

Based on these findings, we have a further hypothesis regarding the DL-SSI learning for the Merapi mine context. Observations during the learning process, the main obstacle that became a critical note was regarding the SSI content. The Merapi mine used as SSI in this study still lacks scientific information, so students are limited in finding further references. Therefore, this fact should be a concern for conducting SSI studies. The SSI criteria worthy of being used as learning resources are SSI with adequate information support.

3.2. The Effects Before and After the Implementation of Discovery Learning Using the SSI Context Toward Students' SRS

The study of SSI is expected to increase students' SRS because the topic of discussion is very close to the socio-cultural situation. In addition, the issues raised are also relevant to everyday life, so after studying SSI, students should have SRS, which increases [47]. However, the findings of this study indicate a different fact after implementing the DL-SSI learning, there was no significant improvement in the SRS of students. Not only in physics but this discrepancy was also found in the context of chemistry, where there was no increase in students' SRS after participating in SSI-themed learning [48].

In light of these findings, we assume that the failure to improve students' SRS occurred due to the relatively short study period. This is because previous studies that have comprehensively assessed SSI and SRS have been carried out in a longitudinal study [47]. This assumption seems reasonable because SRS has habituation characteristics supported by behavioristic theory, meaning that it cannot be constructed in a relatively short time [49].

4. Conclusion

This study proves that in a short time learning science using SSI, especially on the topic of environmental change, does not have a significant impact. In SIS, students' abilities before and after learning are relatively the same. Through cluster analysis, it can be seen that there are significant differences in ability between high and low clusters and moderate and low clusters, but there is no significant difference between high and medium clusters. In SRS ability, it was also found that there was no significant difference between the high and medium groups, but both groups had significant differences from the low clusters. The limitation of this research is the pattern of observation

and learning that takes place quickly and briefly. For further research, the researcher suggests conducting a study with a longitudinal research pattern considering that SIS and SRS are related to behavioristic theory.

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