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Effect of Socio-Scientific Issues Based-Instruction on Critical and Creative Thinking Skills on The Topic of Environmental Change

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Abstract

This study aims to determine: 1) the influence of the Socio-scientific Issues (SSI) based-instruction on critical thinking skills of the students of SMAN 2 Bantul; and 2) the influence of the Socioscaintific Issues based learning on creative thinking skills of the students of SMAN 2 Bantul. SSI learning steps include problem analysis, clarification of science, refocus on socioscientific dilemmas, role playing tasks, and meta-reflective activities. The conflict raised was whether or not a shrimp pond was needed on the southern coast of Bantul Regency and was discussed in the topic of environmental change. This research was a quasi-experimental research type Nonequivalent control group design. The research sample was taken from 2 classes, one class as the experimental class and the other as the control class. The sampling technique used in this study was cluster random sampling. The data were collected using a written test, the observation sheet for the implementation of the learning model and the student response questionnaire. Data were analyzed using one-way ANOVA.The results of this study indicate that: 1). The SSI learning model in Biology learning has a very significant effect on the critical thinking skills of students of SMAN 2 Bantul with a significance value 0.00. This effect is on the aspects of providing simple explanations, developing basic skills, concluding, making further explanations and arranging strategies and tactics.; 2) The SSI learning model in Biology learning has a very significant effect on creative thinking skills in students of SMAN 2 Bantul with a significance value 0.00. This influence on the aspects of fluency, flexibility, originality and elaboration.

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1. INTRODUCTION

Socio-Scientific Issues (SSI) based-instruction aims to stimulate intellectual, moral and ethical development, as well as enable students to understand the relationship between science and social life. As a learning model, SSI consistently raises social issues which require scientific literacy and understanding of scientific concepts and require students to identify questions, gain new knowledge, explain phenomena from a scientific perspective, and make decisions based on scientific considerations. regarding the issue of SSI being granted. SSI promotes science-in-context (SinC) and fosters critical thinking, reflective judgment and social, ethical and moral considerations (Herman, Newton & Zeidler, 2021: 1-43).

The issues developed in SSI-Based Instruction can be local or global issues that are controversial and can be resolved through various scientific fields. In this way, there is a combination of social issues with biological science. Environmental changes that occur as a result of the conversion of Parangtritis sand dunes into shrimp ponds in the southern coastal region of Bantul Regency can be used as a socio-scientific issue in Biology learning. The sand dunes on the south coast of Bantul Regency is one of two barchan type sand dunes in the world. The sand dunes is in Kretek District, Bantul Regency with a total area of 412.8 hectares. This area is divided into a core zone of 141.10 hectares, a supporting zone of 176.43 hectares, and a limited allocation zone of 95.27 hectares (Peraturan Gubernur nomor 5/2019). The strategic area of the Parangtritis sand dunes functions for the development of science and research (Regional Regulation number 4 of 2011), but there has been a conversion of land used for agriculture and shrimp ponds.

The existence of shrimp ponds on the South Coast of Bantul has caused controversy because it is thought to be the cause of environmental degradation. This is evidenced by the reduction in mangrove association plants due to logging for land conversion into shrimp ponds. Failure to manage ponds has resulted in several ponds no longer functioning and becoming empty ponds, which is thought to be the cause of the decline in harvest numbers around the ponds (Afsholnissa, 2018: 2). When these issues are used in learning, students will think about solving problems from various biological perspectives. Students can find out the scientific truth about controversies that occur in society. The assumption that pond water causes crop failure, pollution resulting from leftover feed and medicine in shrimp ponds, groundwater extraction and cutting down of wave barrier trees resulting in abrasion, and various other environmental problems, can be studied from a scientific perspective so that students gain the concept which is intact. Apart from that, students can see directly the economic value of shrimp ponds, job opportunities for local residents, moral values that develop in line with the local wisdom of pond farmers, as well as the role of local government in preparing the Bantul Regency Spatial and Regional Planning Plan, so that insight and knowledge students will develop. This can stimulate the development of critical and creative thinking skills and can apply them in making decisions about whether or not shrimp ponds are needed on the south coast of Bantul Regency.

The application of the SSI learning model to improve learning outcomes has been widely carried out, especially internationally (Sadler & Donnelly (2006: 1463-1488); Nuangchalerm & Kwanthong (2010: 42-47)). Research on the application of SSI in learning provides positive results in improving thinking skills. The research subjects are diverse, ranging from middle school, high school students, prospective teachers, even teachers who have teaching experience. SSI raises students' thinking skills (Subiantoro and Fatkhurohman, 2009: 111-114), the application of SSI in learning allows students to achieve the highest level of argumentation (Herlianti, et al, 2012: 168-177), as well as increasing reflective judgment in junior high school students (Subiantoro , Ariyanti & Sulistyo, 2013: 41-47). The application of SSI to chemistry subjects using discussion and debate methods results in increased critical thinking skills in high school students (Pratiwi, Rahayu & Fajaroh, 2016: 164-170). Learning with the SSI approach in chemistry lessons has a significant influence on improving students' critical thinking skills (Cahyarini, Rahayu, & Yahmin, 2016: 222-229). Learning with SSI can also improve students' creative thinking skills. (Rahmawati, Ratnasari, Suhendar, 2018: 124-132). Thus, the application of SSI in Biology learning at the high school level is expected to provide the same results, so this research aims to determine: 1) the effect of applying the SSI model in Biology learning on students' critical thinking skills at SMAN 2 Bantul, and 2) the effect of applying the SSI model in Biology learning on students' creative thinking skills at SMAN 2 Bantul.

2. LITERATURE REVIEW

2.1. Socio-Scientific Issues based Instruction on Biology Learning

Epistemologically, SSI-based instruction can be called a learning model because it has a theoretical framework of application that can be explained practically in its implementation. In this case, Levinson developed a theoretical framework of the SSI-based learning model based on three foundations of thought, including: 1) elements of conflicting ideas or arguments, 2) communication networks, and 3) mental-thinking abilities used to determine decisions (Subiantoro, 2017: 4). SSI is defined as a representation of issues or problems in social life that are conceptually closely related to science and solutions that are relative or uncertain. According to Sadler, SSI refers to social problems that are dilemmas related to science conceptually, procedurally, and technologically (Subiantoro, Ariyanti & Sulistyo, 2013: 41-47).

According to Zeidler and Nichols (2009: 49-58), SSI is a learning model that involves students in dialogue, discussion and debate to discuss controversial scientific topics in nature, involving the study of moral and ethical values in the learning process until decision making to resolve the topics discussed. The goal is to make learning meaningful and interesting for students, improve critical thinking skills based on real evidence found and provide a context for understanding science. Ekborg, Ideland & Malmberg, (2009: 35-46) describe SSI as

important social issues, and based on science, including building opinions, media reporting, in national and global dimensions, within the framework of political, social, ethical values, and related to understanding opportunities and risks. SSI is one way to learn science through a scientific issues approach, because the problems and issues raised are very significant to natural phenomena. In other words, student activities in learning with the SSI model are a good first step in practicing the theories they receive in real life before they enter society in the future (Saad, et al., 2017: 348-355).

Based on these various opinions, in this study, Socio-Scientific Issues Based Instruction (SSI) is defined as a learning model that engages students in discussions, dialogues, and debates to address controversial science-based social issues in their environment. This enables students to develop critical and creative thinking skills in making decisions regarding environmental issues. This decision-making is based on prevailing societal values and ethics. SSI shares a similar foundation with the STML (Science, Technology, Society, and Environment) approach, but with a fundamental difference: the emphasis on ethical awareness and social values (Subiantoro, 2017: 4). SSI enables a diverse learning process by developing decision-making skills, reflective assessment, guided inquiry, community participation, moral and ethical reasoning, social sensitivity, argumentation skills, and critical and analytical thinking (Sadler, 2009: 1-42).

Learning with SSI modules can improve questioning skills, argumentation skills, and decision-making. SSI promotes thinking with socio-scientific issues to support the development of higher-order thinking skills in science and environmental education (Sadler, 2011: 13). In science education, argumentation on socio-scientific issues, literacy, and the development of critical thinking skills can be developed through SSI-based learning. This is because SSI involves scientific arguments to construct questions, ethics, and actions that must be chosen. Learning with SSI can also improve critical thinking and decision-making skills, engagement in scientific discourse, socio-moral development, and mastery of more sophisticated content with the nature of science (NoS) (Sadler, 2011: 285).

2.2. Critical Thinking Skill

There are many definitions of critical thinking. Haber (2020: 77) describes critical thinking as: (1) the attitude of thoughtfully considering a problem; (2) knowledge of investigative methods and logical reasoning; (3) skills in applying problem-solving methods. Critical thinking teaches an understanding of logical relationships that lead to the ability to analyze, criticize, support ideas, provide inductive and deductive reasoning, draw factual conclusions, and decide on actions based on conclusions based on knowledge or belief. According to Ennis, "Critical thinking is reasonnable reflective thinking focused on deciding what to believe or do" (Widhy, Nurohman & Wibowo, 2013: 159). Critical thinking is reasoned and reflective thinking that emphasizes making decisions about what to believe and do.

Hunter (2014: 3-4) explains Ennis' statement as "deciding to believe involves reasoning about the facts. This is theoretical reasoning. Deciding what to do involves reasoning about what to do and how to do it. This is practical reasoning." The decision to believe a fact is theoretical reasoning, and the decision to believe what to do and how to do it is practical reasoning. Critical thinking is reasoned thinking because it is built on generalizing methods and standards and requires sound reasoning for decision-making. Critical thinking is a reflective ability because it is able to think about a problem from multiple perspectives and simultaneously consider the best method for solving the problem.

According to Ennis, "critical thinking is reflective because it involves thinking about a problem at several different levels or from several different angles all at once, and because it sometimes requires thinking about the right methods to answer or solve a problem." This shows that critical thinking is a way of looking at a problem from multiple perspectives, including determining the best way to solve the problem. (Hunter, 2014: 3-4). Moore and Stanley (2012: 6) explain critical thinking as part of Bloom's taxonomy. Bloom classified levels of thinking and divided them into six levels. The first level represents lower-order thinking and progresses to more complex levels. The six levels of thinking and what they involve are:

1. Knowledge – recalling basic facts and concept
2. Comprehension – demonstration understanding of something learned
3. Application – using information already learned in a new way
4. Analysis – breaking information into parts and examining those parts by looking for relationship
5. Synthesis – taking something apart and creating something new
6. Evaluation – judging something based on a set of criteria

Analysis, synthesis, and evaluation are considered to be the higher levels of thinking and thus are invaluable tools for integrating critical thinking into both curriculum and formative assessment. The idea is to provide the student with the rigor necessary to be succesful both today and in tomorrow’s world.

Based on this opinion, the level of critical thinking skills is not simply memorizing facts but rather involves the stages of analysis, synthesis, and evaluation. Critical thinking involves the use of deductive and inductive

reasoning skills. Analysis, synthesis, and evaluation are considered higher levels of thinking and are therefore invaluable tools for integrating critical thinking into the curriculum and formative assessment.

To measure the level of critical thinking, knowledge tests can be used. Another form of critical thinking skill assessment is formative assessment. This assessment can be used in the learning process, through debate activities or case studies (Haber, 2020: 107-108). Written tests can be used to measure critical thinking skills.

In practice questions, students are confronted with a new problem or situation that requires them to assess the situation and determine an acceptable solution using their knowledge of the subject being studied and their reasoning skills. By using graphs, images, or reading material, students are assessed at a higher cognitive level. To answer interpretation questions, students must understand the material being interpreted. Students must understand the question, then identify and access information that can be used to help interpret the data. Students must be able to connect new information to their existing knowledge. To connect new information to existing knowledge, students need the following skills: 1) to express effective reasoning; 2) to use systems thinking; 3) to make judgments and decisions; and 4) to solve problems. Stobaugh (2013: 3) explains that these four skills are aspects of critical thinking skills as part of 21st-century life skills.

In this study, critical thinking skills were measured using a written test that measured the five aspects as formulated by Ennis. These five aspects are described in indicators that synthesize the opinions of Ennis, Linn, and Gronlund. The test items were developed based on the examples provided by Moore and Stanley. The topic used in this study was Environmental Change, so critical thinking skills were measured using a written test on environmental change, with the indicators in Table 1 below.

Table 1. Aspects and indicators of critical thinking skills

Aspects of critical thinking	Critical Thinking Skills Indicators
Memberikan penjelasan sederhana (elementary clasification)	Compare
	Cause and effect relationship
	Give reasons
Build basic skills	Summarizing
	Argue
	Grouping
	Analysis
	Synthesis
Conclude	Evaluation
	Conclusion
Make further explanations.	Implementing
Set strategy and tactics.	Creating

(source: synthesis of opinions of Ennis, Linn, Gronlund in Rosana, 2014: 396-397).

2.3. Creative Thinking Skill

According to Perkins (Rosana, 2014: 392), creative thinking is defined as the ability to form new combinations of ideas to meet a need or to obtain an original result (product) that meets the criteria of the question. According to Ramalingam et al. (2020: 5), creative thinking is the ability to generate a variety of ideas, manipulate ideas in unusual ways, and make connections to elegantly unravel unsolved problems. According to Reisman (2015: 169), one of the principles of critical thinking skills is connecting "wild" and "crazy" thoughts into associations that produce creative ideas.

The optimal development of students' creative thinking skills in a learning environment is closely related to the teacher's teaching style. Teaching and interaction patterns that provide more trust, appreciation, and encouragement for students' ability to find solutions to each teaching situation they encounter will foster greater courage to try, propose, and explore new ideas or methods, which are the seeds of creativity (Rosana, 2014: 393).

Creativity is an individual's ability to use imagination and the various possibilities derived from interactions with ideas, other people, and the environment to create new and meaningful connections and outcomes. Creativity expresses a better quality of solution. Different perspectives will stimulate diverse ideas and develop new cognitive structures. According to Ramalingam et al. (2020: 2-3), creativity has the potential to improve the quality of life. Creativity is as important as the formal academic domain and is greatly needed in the context of a constantly changing world. Teaching that emphasizes increasing creativity has a positive impact on student achievement.

Creativity is a multidimensional construct, comprised of several dimensions: cognitive (creative thinking), affective (attitude and personality), and psychomotor (creative skills). According to Munandar (2014: 192), each dimension encompasses various categories. The cognitive dimension encompasses fluency, flexibility, originality in thinking, and the ability to elaborate. Similarly, Reisman (2015: 171) describes several characteristics that can be used to assess creative thinking skills, namely openness to new ideas, suspension of judgment on ideas, fluency in seeking as many ideas as possible, flexibility in exploring as many realms and fields of inquiry as possible, elaboration, resilience to mature premature ideas before implementation, enthusiasm for complex issues, ability to distinguish between divergent and convergent thinking patterns, courage to take risks, high intrinsic motivation, persistence, and maintaining originality.

Creativity assessment can be conducted in various ways. Ramalingam et al. (2020: 3) explain that creativity assessment can use the following categories: 1) divergent thinking (DT) assessment; 2) personal creativity assessment; 3) checklist of activities and experiences related to productivity; 4) attitude scale; and 5) product assessment. Kaufman & Sternberg (2010: 48-56) explain that creativity measurement follows Torrance's (1979) opinion.

Creativity tests tend to be of two types—those that involve cognitive-affective skills, such as the Torrance Tests of Creative Thinking, and those that attempt to tap a personality syndrome, such as the Alpha Biological Inventory. Some educators and psychologists have tried to address the issue of whether each creativity is essentially a personality syndrome that includes openness to experience, adventuresomeness, and self-confidence, and whether the cognitive processes of rational and logical thinking in creative thinking are precisely the same as those used by high-IQ children. The Torrance Test of Creative Thinking is a test used to measure creative thinking skills with four assessment scales, namely: 1) fluency, which describes the number of ideas generated in response to stimuli; 2) flexibility, which is the number of different categories of relevant responses; 3). Originality, which is the statistical rarity of responses; and 4) elaboration, which describes the amount of detail in responses. (Reisman, 2015: 14).

In this study, creative thinking skills were measured using a written test based on level 1 indicators: fluency; flexibility; originality; and detail. The aspects and indicators are shown in Table 2 below.

Table 2. Aspect and Indicators of Creative Thinking Skills

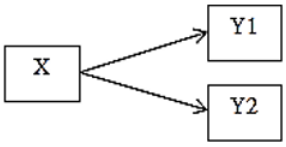
Aspect	Indicators of Creative Thinking Skills
Fluency	Generating many ideas or answers
	Fluent in expressing ideas
flexibility	Generating diverse ideas
	Able to change methods or approaches in determining and analyzing a phenomenon encountered
Originality	Providing unconventional answers
	Able to generate ideas
Detail	Elaborating on a problem
	Enriching an idea

(source: synthesis of Torrance's opinion in Reisman (2015: 14)).

3. RESEARCH METHOD

The research design used in this study was a Nonequivalent Control Group Design. In this design, two groups were selected based on specific considerations, then given a pre-test to determine the conditions of the experimental and control groups. The population consisted of all tenth-grade students at SMAN 2 Bantul. The sample was taken using a cluster random sampling technique. Sugiyono (2011:150-151) explains that this technique involves two stages: first, determining the sample area and second, determining the sample participants. This technique was used because it is very difficult to change the classroom arrangements established by the school. In this case, both classes had equivalent average academic achievement in Biology in the first semester. Each class had 30 students.

The research variables consisted of one independent variable and two dependent variables, with the relationship depicted in Figure 1 below.



Information:
X : independent variable, SSI based instruction
Y1 : dependent variable, critical thinking skills
Y2 : dependent variable, creative thinking skills

Figure 1. Relationship Between Research Variables

Data collection was conducted through written tests, observations during the learning process, and student response questionnaires regarding the implementation of the learning. Data collection instruments included test kits, worksheets (LKS), observation sheets, and questionnaires. The tests were conducted to measure students' critical and creative thinking skills. The worksheets were used to determine critical and creative thinking skills during the learning process. The observation sheets were used by observers to assess the implementation of SSI-based learning. The questionnaires were used to obtain supporting data, namely the implementation of learning with the Socio-scientific Issues model according to students' views.

The data obtained were analyzed quantitatively. The prerequisite tests used included homogeneity and normality tests. Hypothesis testing was conducted using one-way ANOVA. The difference in pre-test and post-test scores was calculated using the following formula formulated by Hake (Hartati, 2016).

$$N - Gain = \frac{Spost - Spre}{Smaks - Spre}$$

Information :
Spost : average of postest
Spre : average of pretest
Smaks : ideal maximum score

Figure 2. Calculation Formula of N-Gain

The criteria for the N-gain calculation results are as follows.

Table 2. Interpretation of N-Gain Scores

Score N-Gain	Criteria
N-gain ≥ 0,71	High
0,31 ≤N-gain ≥ 0,70	Medium
N-gain < 0,30	Low

(source: Hake (1999) in Hartati (2016))

4. RESULT AND DISCUSSION

The results of the homogeneity and normality tests of the data show that the data on critical and creative thinking skills are normally distributed and homogeneous, both in the pre-test and post-test data. Hypothesis testing was carried out using a one-way ANOVA test to determine the effect of the SSI learning method on improving students' critical and creative thinking skills. The following table summarizes the results of the one-way ANOVA analysis.

Table 3. Results of One-Way ANOVA Test

Anova Analysis Results						
	Sum of Squares		df	Mean Square	F	Sig.
Critical Thinking Skills	Between Groups	1066.311	1	1066.311	25.13 6	.00 0
	Within Groups	2460.471	58	42.422		
	Total	3526.782	59			
Creative Thinking Skills	Between Groups	1627.604	1	1627.604	43.42 3	.00 0
	Within Groups	2173.988	58	37.483		
	Total	3801.593	59			

Based on the analysis results, it was found that the comparison value between groups (between groups) was smaller than the variation within groups (within groups) for both critical thinking skills and creative thinking skills data. This indicates a difference in learning outcomes between the control and treatment classes. The difference in results was very significant, indicated by a significance value of 0.00, for both critical thinking skills and creative thinking skills data. Thus, the use of the SSI learning model has a significant effect on improving critical and creative thinking skills.

4.1. The Effectiveness of SSI Learning on Students' Critical Thinking Skills

Critical thinking skills are skills that must be continuously practiced by students. These skills include identifying cause-and-effect relationships, providing reasons, summarizing, concluding, expressing opinions, classifying, analyzing, synthesizing, evaluating, applying, and creating. In this study, indicators of these critical thinking skills were tested through pretests and posttests. The questions used were multiple-choice reasoning questions. This type of question allows students to explain the reasons for their choice of the correct answer.

The pretest and posttest results from the control and SSI classes were then analyzed and compared. N-gain was calculated from the pretest and posttest scores to determine the improvement after the treatment. The results of the analysis are shown in the following diagram.

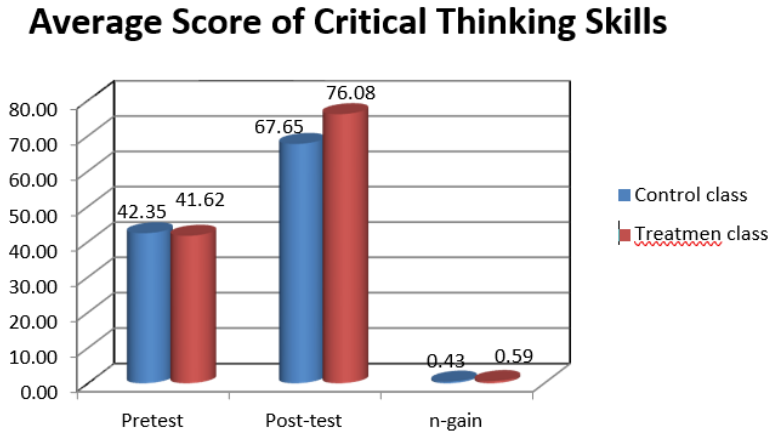


Figure 3. Average Score of Critical Thinking Skills

Based on the diagram, the increase in post-test scores in the SSI class was higher than in the control class. The n-gain in the SSI class was 0.59, or "moderate," while the n-gain in the control class was 0.43, or "low." This is due to the differences in learning methods. Controversial issues in SSI encourage students to be more active in discussions and debates. Through these discussions, students share individual perspectives, gain an understanding of subjective variations within the group, make choices between differing values, and find rational solutions to controversial issues (Ratchliffe & Grace, 2003: 92). This will train their critical thinking because SSI involves both scientific and social issues, forcing students to consider the impacts of both sides.

The controversial issue of shrimp ponds on the southern coast of Bantul Regency, raised in the SSI class, requires students to understand concepts related to environmental change and its socio-economic impacts on community life in the short and long term. The large-scale use of diesel fuel to power windmills and draw seawater into each pond, the use of antibiotics, the disposal of liquid waste, and the post-harvest management of ponds provide students with a concrete understanding of human activities and their impact on the environment. Students can compare the condition of the land surrounding the ponds with the sandy beach area, which has naturally been left to develop into sand dune and coastal ecosystems. Students can also observe abandoned ponds, allowing the process of succession to begin. The facts they encounter in the field are compared with theories they have learned from various sources, strengthening biological concepts related to environmental change. Students can connect pieces of their knowledge into a coherent understanding that can be applied in their social lives. Thus, SSI fosters the development of critical thinking skills better than conventional classroom learning. This is consistent with research conducted by Pratiwi, Rahayu, and Fajaroh (2016), Chun-Yen Tsai (2017), and Ismawati and Pertiwi (2019).

Critical thinking skills were measured using five aspects, each consisting of several indicators synthesized by Ennis, Linn, and Gronlund. A comparison of pretest and posttest results, as well as gains in the control and SSI classes, is presented in Table 4 below.

Table 4. Comparison of Critical Thinking Skills in each Aspect in the Control and Treatment Classes

No	Aspect	Control class			Treatment class		
		Pre test	post test	n- gain	Pre test	post test	n-gain
1	providing simple explanations	43.75	65.83	0.39	34.03	72.64	0.59
2	building basic skills	41.58	67.17	0.44	47.00	78.33	0.59
3	concluding and evaluating	46.67	62.92	0.30	50.00	81.25	0.63
4	creating further explanations	42.92	71.25	0.50	47.50	78.33	0.59
5	organizing strategies and tactics	39.17	69.17	0.49	26.25	70.83	0.60

The table shows that the average posttest score for each aspect in the SSI class was higher than in the control class. The highest n-gain for the control class was in the aspect of providing further explanations, although the figure was lower than in the SSI class. In the SSI class, the highest gain score was in the aspect of concluding and evaluating. In general, the n-gain for each aspect in the SSI class was higher than in the control class. This indicates a difference in changes in students' critical thinking skills before and after the treatment. The SSI learning model is able to develop critical thinking skills at a higher level than the conventional model.

4.1.1. Aspects Provide Simple Explanations

The aspect of providing simple explanations in this study was measured using indicators such as comparison, cause-and-effect relationships, and reasoning. The average posttest score for the SSI class was 72.64, with moderate gains. In the control class, the average final score was 65.83, with low gains. This difference in results is due to differences in student treatment. During the learning process, students in the SSI class observed and compared environmental changes directly through outdoor observations, while students in the control class observed them from pictures or videos. This enabled students in the SSI class to be more capable of providing reasoning, as indicated by research by Saad et al. (2017), who identified cause-and-effect relationships and compared environmental changes they encountered by directly studying the locations where these environmental changes occurred. Herlanti et al. (2012) revealed that students achieved the highest level of argumentation through learning with SSI content. This confirms that the aspect of providing simple explanations develops well through SSI-based learning.

Students in the SSI class received a better learning experience than students in the control class by bringing real-world issues into the classroom or taking students to environments outside the classroom. Through contextual learning, students can directly observe the causes of environmental change, human activities that have direct and long-term impacts on environmental sustainability, and environmental efforts to return to a stable state after damage. Through place-based SSI instruction, students develop and express an ecological perspective, recognizing the interdependence between humans and nature. Humans are an inseparable part of nature, and claims that technology will improve all human needs must be accompanied by personal responsibility and a moral commitment to pro-environmental action. (Herman, Newton, & Zeidler, 2021)

4.1.2. Building Basic Skills

This aspect was measured using indicators such as summarizing, arguing, grouping, analyzing, and synthesizing. The average posttest score for the SSI class was 78.33 with a moderate n-gain, while in the control class it was 67.17 with a moderate gain. The average score for students in the SSI class was higher than the control class. Students in the SSI class played role-plays with different roles. This method empowered students to debate, even if their opinions were incorrect. While student opinions may differ, this provided a rich learning experience in the classroom (Mueller & Zeidler, 2010).

In the control class, students engaged in group discussions and presentations. Not all students expressed their opinions or ideas, leading to some dominant students in group work. In the SSI class, each student was required to express their opinions based on data and facts gathered through outdoor activities. Students were able to utilize diverse knowledge and convey diverse ideas (Nuangchalerm, 2010) using facts and data gathered during the learning process. The process of discussing SSI issues will foster students' critical thinking skills, as demonstrated by research by Subiantoro and Fatkhurohman (2009). Thus, summarizing, grouping, analyzing, and synthesizing skills can also develop well, alongside their ability to express opinions.

4.1.3. Cloncuding and Evaluating

This aspect is measured using the summarizing and evaluating indicators. Summarizing involves establishing and summarizing opinions based on the facts described, and determining an alternative from among various available action options, which is the best decision to implement. The average posttest score for the SSI class was 81.25 with a moderate n-gain, while the average score for the control class was 62.92 with a low n-gain.

Learning using the SSI model improves summarizing and evaluating skills (Lathifah & Susilo, 2015) and can enhance decision-making skills (Subiantoro, Ariyanti, Sulistyo, 2013). SSI-based learning helps students improve their skills in analyzing, evaluating, and concluding large amounts of information related to SSI (Gul and Akcay, 2020).

4.1.4. Creating Further Explanations

This aspect is measured by the indicator of being able to apply knowledge to solve real-life cases. The average posttest score for the SSI class was 78.33 with a moderate n-gain. The average posttest score for the

control class was 71.25 with a moderate n-gain. This difference in results indicates that the learning process within the SSI context can improve decision-making skills and their application in action or use in problem-solving.

4.1.5. Organizing Strategies and Tactics

This aspect is measured by the ability to create or communicate ideas about problem-solving. The average posttest score for the SSI class was 70.83 with a moderate n-gain. The average posttest score for the control class was 69.17 with a moderate n-gain. This indicates that the SSI learning model is able to improve creative skills better than conventional learning.

In the SSI class, students directly observed the environmental issues that were the focus of the discussion. Students understood the controversy surrounding the necessity of shrimp ponds on the south coast of Bantul Regency in relation to environmental change, thus improving their ability to develop ideas for solving existing problems. Students were able to develop their creativity by considering the fundamental need for environmental improvement in their learning location. Students conducted interviews and sought various information and data sources to support problem-solving efforts through various creative means.

Creating are at the highest level in Bloom's taxonomy. Through learning with the SSI model, this ability was honed, resulting in an increase in the average posttest score compared to the pretest. When compared with the control class, the improvement in the SSI class was much higher. If we look at the development for each indicator, the changes in the critical thinking abilities of students in the control class and the SSI class as measured by the pretest and posttest scores are shown in Table 5 below.

Table 4. Achievements per Critical Thinking Indicator in Control and Treatment Classes

No	Critical thinking indicators	Control class		Treatment class	
		Pre Test	Post Test	Pre Test	Post Test
1	Comparing	62.50	63.33	30.00	69.17
2	Causal Relationships	41.67	68.33	39.58	75.00
3	Giving Reasons	27.08	65.83	32.50	73.75
4	Summarizing	25.83	61.67	33.33	75.00
5	Giving Opinions	45.00	71.67	46.67	80.00
6	Grouping	31.67	70.83	44.17	71.67
7	Concluding	68.33	69.17	65.83	82.50
8	Analyzing	54.58	75.83	50.83	80.83
9	Synthesizing	50.83	55.83	60.00	84.17
10	Evaluating	25.00	56.67	34.17	80.00
11	Applying	42.92	71.25	47.50	78.33
12	Creating	39.17	69.17	26.25	70.83

The table shows that students' critical thinking skills improved in both the control and SSI classes. A comparison of the improvement in each indicator across the two treatments is shown in Table 6 below.

Table 6. Comparison of N-Gain Per Indicator in Control Class and Treatment Class

No	Indicators of Critical Thinking Skills	Control class		Treatment class	
		n-gain	Criteria	n-gain	Criteria
1	Comparing	0.02	Low	0.56	Medium
2	Causal Relationships	0.46	Medium	0.59	Medium
3	Giving Reasons	0.53	Medium	0.61	Medium
4	Summarizing	0.48	Medium	0.63	Medium
5	Giving Opinions	0.48	Medium	0.63	Medium
6	Grouping	0.57	Medium	0.49	Medium
7	Concluding	0.03	Low	0.49	Medium
8	Analyzing	0.47	Medium	0.61	Medium

9	Synthesizing	0.10	Low	0.60	Medium
10	Evaluating	0.42	Medium	0.70	Medium
11	Applying	0.50	Medium	0.56	Medium
12	Creating	0.49	Medium	0.63	Medium

Considering the n-gain for each treatment, the use of the SSI model significantly improved critical thinking skills. The table shows that SSI increased students' ability to synthesize (0.60) significantly more than the control class (0.10). This was primarily formed through real-world learning experiences that enabled students to analyze problems and draw conclusions based on well-collected data. The increase in the ability to conclude in the SSI class (0.49) was significantly higher than in the control class (0.03). Similarly, the increase in the ability to compare was 0.56 in the SSI class, significantly higher than the control class (0.02).

During the learning process, both the SSI and control classes were guided by worksheets. Students worked on these worksheets in groups. The average worksheet score for the SSI class was 70.07 and the control class was 71.88. These averages were not significantly different. This indicates that the learning model used by teachers in both classes was indeed able to facilitate the development of critical thinking skills. However, individually, students in the SSI class demonstrated higher levels of critical thinking skills than those in the control class. Table 7 below shows the critical thinking achievement levels of students in the control and SSI classes and Treatment Class.

Table 7. Comparison of Critical Thinking Skill Levels of SSI and Treatment Classes

Critical Thinking Skills Criteria	**Control class**				**Treatment class**			
	Pre Test		Post Test		Pre Test		Post Test	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Not critical	11	36.67%	0	0.00%	14	46.67%	0	0.00%
Less critical	18	60.00%	0	0.00%	15	50.00%	0	0.00%
Quite critical	1	3.33%	11	36.67%	1	3.33%	1	3.33%
Critical	0	0.00%	17	56.67%	0	0.00%	20	66.67%
Very critical	0	0.00%	2	6.67%	0	0.00%	9	30.00%

In the initial conditions, students in both classes were at the non-critical, less critical, and quite critical levels. After the treatment, 16.67% of the SSI class students managed to reach the very critical level, while only 3.33% of the control class students. In the control class, 36.67% of students were still at the quite critical level, while only 3.33% of the SSI class students were at the critical level. More students were at the critical level in the SSI class than in the control class. From these results, it can be seen that the real effect of the SSI learning model on improving students' critical thinking skills.

4.2 The Effectiveness of SSI Learning on Students' Creative Thinking Skills

Creative thinking skills are one of the 21st-century skills that must be developed in students. The value of creative thinking skills in this study was measured based on the aspects of fluency, flexibility, originality and detail. Fluency includes the ability to generate many ideas and express ideas, flexibility includes generating diverse ideas and changing methods or approaches, originality includes providing unusual answers and generating ideas related to problems and detail which includes detailing a detail and enriching ideas. Data were collected before and after treatment. The increase in ability is indicated by n-gain. Figure 3 below shows the average achievement of creative thinking skills scores from the control class and the SSI class.

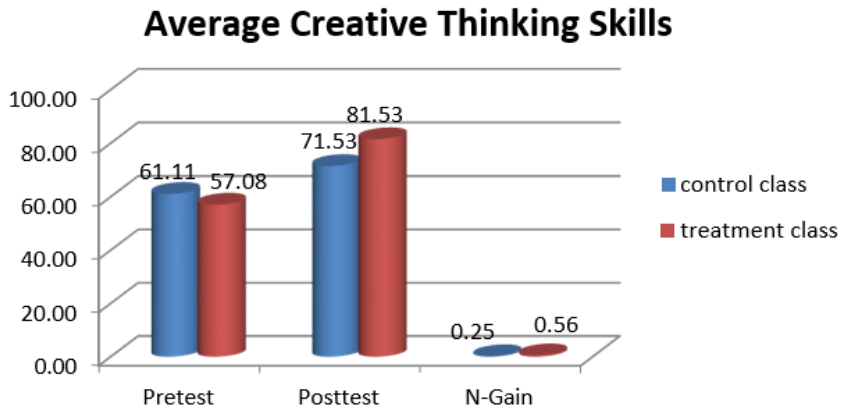


Figure 4. Graph of Average Creative Thinking Skills

Based on the graph, it is known that there was a difference in the average posttest results for the SSI class, which was higher than the control class. The n-gain for the SSI class was 0.56, or "moderate," while the n-gain for the control class was 0.25, or "low." When broken down by aspect, the improvement in creative thinking skills for students in the control and SSI classes is as follows.

Table 8. Achievement of Creative Thinking Skills

No	Skills Aspects Creative Thinking	***Pre test***		***Post test***		**n-gain**	
		Kontrol	SSI	Kontrol	SSI	Kontrol	SSI
1	Fluency	61.67	62.17	77.33	92.33	0.41	0.80
2	Flexibility	57.33	48.33	69.00	88.33	0.27	0.77
3	Originality	64.50	67.67	77.83	81.00	0.38	0.41
4	Detail	61.00	50.00	62.33	64.50	0.03	0.29

During the learning process, students were guided by worksheets (LKS) containing work instructions and supporting the development of their thinking processes. The worksheets were completed in groups. The average LKS score between the SSI class (75.21) and the control class (77.33). This indicates that the learning process in both classes was able to develop creative thinking skills. In fact, the control class produced higher scores on the LKS than the SSI class. Thus, the differences in posttest results indicate the individual development of students in both classes.

4.2.1 Fluency

Fluency was measured using indicators such as generating a large number of ideas or answers related to environmental change and fluency in expressing ideas related to environmental change. Students were given descriptive questions related to these two indicators. Student answers were recorded and compared with those of other students to determine a score for each question. The posttest results showed an n-gain of 0.80 for the SSI class, which is considered high. The average posttest score for the SSI class was 92.33, while the average posttest score for the control class was 77.33, with an n-gain in the moderate category. This indicates that learning in the SSI class contributes to improving fluency better than conventional classes.

4.2.2 Flexibility

The flexibility aspect is measured by generating diverse ideas related to environmental change and the ability to change methods or approaches in defining and analyzing a phenomenon encountered related to environmental change. The average posttest score for the SSI class was 88.33, with a high n-gain, while the control class scored 69.00, with a low n-gain. This indicates that SSI learning fosters the development of flexibility in students' thinking patterns.

In this aspect, SSI class students generated more diverse ideas than control class students. The learning process in the SSI class, addressing the controversial issue of shrimp farms on the southern coast of Bantul Regency related to environmental change, took both scientific and social perspectives. The scientific content covered pollution, covering its causes, impacts, and solutions, including the use of technology in shrimp farm activities, habitat changes, environmental improvement efforts, and waste management. The social content covered economic, social, and legal issues. Both content encouraged students to think from two perspectives to formulate the most appropriate opinions and conclusions, resulting in a wide variety of student ideas in the class.

4.2.3 Originality

Originality means authenticity, the ability to provide unconventional, unique answers, and those rarely offered by most people. This aspect is measured by the ability to provide unconventional answers related to environmental change issues and the ability to generate ideas related to environmental change issues from an economic, social, and legal perspective. The average post-test score for the SSI class was 81.00, a slight difference from the average score for the control class, which was 77.83. The n-gain for both classes was within the moderate range. This indicates that both treatments improved originality, but the results for the SSI class were higher than those for the control class.

4.2.4 Detail

The improvement in the detailing aspect in this study was the lowest compared to other aspects, both in the SSI and control classes. The mean post-test score for the SSI class was 64.50 and the control class was 62.33. The n-gain in both classes was in the low category. Detailing was measured by the indicators of detailing a problem related to environmental change and enriching an idea related to environmental change. Both classes demonstrated low achievement. To enrich an idea, students must have extensive knowledge and high scientific literacy. This ability will support the development of creative thinking skills. If students have broad insight, it will be easier for them to propose various ideas and detail problems, thus generating creative solutions. This ability still needs to be developed in both classes.

Judging from the variation in answers, the number of variations in post-test answers for each indicator increased compared to the pre-test. Students' answers in the SSI class were more varied than those in the control class. The increase in variation in student answers was highest for the indicator of fluency in expressing ideas, while the lowest was for the indicator of detailing a detail. Regarding the indicator of presenting unconventional answers, students in the control class actually experienced a decrease in response variation. This is because learning in the control class always concluded with a conclusion on a topic being discussed, thus fostering consensus on answers within the class. In the SSI class, conclusions can be drawn from diverse perspectives and academic backgrounds. Concepts about environmental change are formed by students through broader learning experiences, direct interaction with the learning environment and community, allowing for direct application of theory in real life. Table 9 below summarizes the number of response variations among students in the control and SSI classes.

Table 9. Variation Answer of Creative Thinking Skills Test

Number of Answer Variations							
No	Creative Thinking Skills Aspects	Control class		Treatment class		Difference	
		Pretest	postest	Pretest	postest	Control	Treatment
1	Fluency (generating many ideas)	19	20	19	28	1	9
2	Fluency (smoothly expressing ideas)	17	31	14	42	14	28
3	Flexibility (generating diverse ideas)	13	16	7	16	3	9
4	Flexibility (changing methods or approaches)	7	8	7	12	1	5
5	Originality (unconventional answers)	17	15	18	23	-2	5
6	Originality (generating ideas related to the problem)	17	18	15	24	1	9
7	Detail (exploring details)	16	16	17	19	0	2
8	Detail (enriching ideas)	16	17	13	21	1	8

The table shows that SSI improves all aspects of creative thinking skills. The variation in student responses indicates the development of insight, more creative thinking, and flexibility. When viewed individually, the increase in creativity levels is evident in Table 10 below.

Table 10. Comparison of Creative Thinking Skills of Treatment Class and Control Class Students

	Treatmen class				**Control class**			
	Pre Test		Post Test		Pre Test		Post Test	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
not creative	0	0.00	0	0.00	0	0.00	0	0.00
less creative	15	50.00	0	0.00	10	33.33	0	0.00
quite creative	9	30.00	0	0.00	9	30.00	4	13.33

creative	6	20.00	15	50.00	11	36.67	25	83.33
very creative	0	0.00	15	50.00	0	0.00	1	3.33

The table shows that the initial conditions between the control and SSI classes were nearly identical. Students were at the less creative, moderately creative, and creative levels. In the control class, the number of students at the creative level was even higher than in the SSI class. After the treatment, 50% of the SSI class students were at the creative level and 50% at the highly creative level. In the control class, 13.33% of students were at the moderately creative level, 83.33% were at the highly creative level, and only 3.33% of students reached the highly creative level. In both classes, there were no more students at the less creative level.

The increase in the number of students reaching the highly creative and creative levels in the SSI class indicates that the learning method is able to stimulate the development of students' creative thinking. These results align with research by Rahmawati, Ratnasari, and Suhendar (2018). In this study, SSI improved sensitivity, detail, fluency, flexibility, and originality. Learning activities using the Socioscientific Issues approach, which raises issues within students' environments, can stimulate students to develop ideas or concepts to solve emerging problems, ultimately enhancing students' creative thinking skills. This aligns with Zeidler, Herman, and Sadler (2019)'s perspective on the SSI learning environment, which provides learning experiences based on local wisdom, authentic regional characteristics, a transdisciplinary synthesis of science and culture, and interaction with the community. This is crucial given that SSI utilizes methods of argumentation, debate, discussion, and other forms of discourse as a means to engage the thinking and reasoning process, thereby enhancing critical and creative thinking skills.

5. CONCLUSION

Data analysis using one-way ANOVA yielded a significance value of 0.00 for both critical thinking and creative thinking skills. Thus, the use of the SSI learning model significantly impacted the critical and creative thinking skills of students at SMAN 2 Bantul.

The impact on critical thinking skills was seen in the following aspects: providing simple explanations; developing basic skills; drawing conclusions; developing further explanations; and organizing strategies and tactics, with an n-gain of 0.59. The impact on creative thinking skills was seen in the following aspects: fluency; flexibility; originality; and detail, with an n-gain of 0.56. This improvement in critical and creative thinking skills occurred because:

a) SSI implemented Science-in-Context (SinC). Students learned Biology material with controversial social issues in the community, making learning more meaningful.
b) Students learned directly through outdoor learning at the learning location, enabling them to compare the environmental changes they encountered with the theories they had learned. This stimulated students to explore further the phenomena they encountered in the field, further honing their critical and creative thinking skills.
c) Students role-play and engage in conflict resolution negotiations based on biology concepts. This requires students to reason critically and creatively.
d) Student participation in the treatment class was high (95.67%). Using the SSI model, students were able to formulate scientific reasoning, argue, participate in data collection and analysis, and participate in decision-making within their groups.
e) Students were encouraged to reflect on the overall learning experience and the underlying scientific concepts, thus fostering the development of critical and creative thinking skills.

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