



## Critical thinking skills on global warming issue: Effect of the socio-scientific problems approach on problem-solving toward student's

Rizqi Yanuar Pauzi\*, Sistiana Windiaryani

Biology Education, Faculty of Education and Education Science, Muhammadiyah University of Sukabumi, Indonesia

\*Corresponding author: [rizkiyanuar85@yahoo.com](mailto:rizkiyanuar85@yahoo.com)

### ARTICLE INFO

#### Article history

Received: 17 February 2021

Revised: 27 April 2021

Accepted: 16 July 2021

#### Keywords:

Critical thinking skills

Global warming

Socio-scientific issues



### ABSTRACT

This study aims to investigate the effect of socio-scientific issues learning approaches on problem-solving learning model toward improving the critical thinking skills of Islamic junior high public school students on global warming issue. The method used in this research was a quasi-experimental with a nonequivalent control group design. This study was conducted at one of the Islamic junior high public schools in Sukabumi with a research sample of class VII C as the experimental group and class VII B as the control. The sampling technique used was purposive. The instrument used was a test of critical thinking skills in the form of essays with as many as 9 items and questionnaires to investigate the response of students toward learning thought 10 statements. The result of the research showed the average value of the experimental class N-gain of 0.38, which is higher than the control class of 0.24. Test of the difference in average critical thinking skills in the experimental class and control class using the t-test of N-gain data showed  $t\text{-count } 3.800 > 2.009 \text{ t-table}$ , therefore  $t\text{-count} > t\text{-table}$ , then  $H_0$  rejected and  $H_1$  accepted. So it can be concluded that the socioscientific issues learning approach affect the ability of student's critical thinking on global warming issue. Based on these results, we suggest that the socio-scientific issues learning approach can be applied by teachers in school for teaching with other socio-scientific issues such as genetic, ecology, and biodiversity.

© 2021 Universitas Negeri Jakarta. This is an open-access article under the CC-BY license (<https://creativecommons.org/licenses/by/4.0>)

Pauzi, R. Y., & Windiaryani, S. (2021). The critical thinking skills on global warming issue: Effect of the socio-scientific problems approach on problem-solving toward student's. *Biosfer: Jurnal Pendidikan Biologi*, 14(2), 228-236. <https://doi.org/10.21009/biosferjpb.19963>

## INTRODUCTION

Within the framework of the 21st century, competence shows that knowledge through core subjects alone is not enough. It must be equipped with the ability to think creatively-critically (Partnership 21st Century Skill, 2002). This shows that students are required to develop critical thinking skills in the learning process as part of the nature of science. Besides, changes in learning patterns in the 2013 curriculum that require students to be critical in learning are also one indicator of the importance of this critical thinking skills to be trained and owned by students. Sudiarta (2009) states that critical thinking has been proven to prepare students to think in various disciplines because critical thinking is a cognitive activity undertaken by students by dividing the way of thinking into real activities by focusing on making decisions about what is believed or done.

Based on the results of observations at school, learning carried out in the classroom by the teacher has not fully trained students' critical thinking skills. The teacher always uses direct learning with the lecture method and trains questions to students without the process of discussion and scientific steps. The socio-scientific issues learning approach is expected to develop students' critical thinking skills. Socio-scientific issues are a strategy that aims to stimulate intellectual, moral, ethical development, argumentation, and awareness about the relationship between science and social life (Zeidler et al., 2005; Nuangchalerm, 2010; Bosser & Lindahl, 2020). The recent research was conducted by Susilawati (2020) showed that socio-scientific issues can improve environmental awareness. Besides, socio-scientific issues can promote students' responsibility for sustainable development, self-efficacy for environmental issues, and environment-related activities significantly by using topics such as organic agriculture, genetically modified food, marine biodiversity, and animal ethics (Wang et al., 2018).

Based on research conducted by Latifah & Susilo (2015) that socio-scientific issues learning approach can improve critical thinking skills. In their research mentioned that the problem-solving ability of students is better after applying the socio-scientific issues learning approach. The results of these studies indicate that the socio-scientific issues learning approach plays a role in students' critical thinking skills. Furthermore, research conducted by Subiantoro et al. (2013) states that socio-scientific issues learning can improve students' reflective judgment. Whereas in Gutierrez (2015) study socio-scientific issues learning can improve decision-making skills. From several studies that have been conducted show that socio-scientific issues learning not only focuses on developing thinking skills but also influences the attitude of students.

Zeidler et al. (2005) state that learning socio-scientific issues has several benefits, namely, (1) growing scientific literacy in students so that they can apply evidence-based science knowledge in daily life, (2) the formation of social awareness in which students can reflect on the results of reasoning they, (3) encourage the ability of argumentation to the thought process and scientific reasoning of a phenomenon that exists in the community, and (4) enhance critical thinking skills which include analyzing, making conclusions, giving explanations, evaluating, interpreting, and doing self-regulation.

The socio-scientific issues learning approach can be combined with problem-based learning models. For example, research conducted by Subiantoro et al. (2012) and Subiantoro, Handziko, & Wibowo, (2021) uses a problem-based learning model combined with socio-scientific issues approach. However, in this study the model used is the problem solving learning model because the problems to be solved are not real and only solved through a discussion process. Gulo (2002) states that problem solving is a method that teaches problem solving by emphasizing the solving of a problem in a logical manner. Sanjaya (2013) states that problem solving is a learning model that can improve students' critical thinking skills. Based on the definitions above, it can be concluded that problem solving is a learning approach that

requires students to solve a problem scientifically so that they can improve their critical thinking skills.

In this study, the material chosen is about the concept of global warming. The global warming issue used in this study is a drought that occurred in Sukabumi as an impact of global warming. The use of global warming material in the socio-scientific issues learning has been carried out by Nuangchalerm (2010) but in this study, researchers used a different issue. This drought issue is very suitable to be used because it involves biological concepts and social problems.

The critical thinking skills of Indonesian students is one of our concern to make betterment in the future. This is because Indonesia was ranked 62<sup>nd</sup> out of 70 countries in the aspect of scientific literacy according to the 2015 Program for international Student Assessment (OECD, 2015). Based on the 2015 Tren in Internasional Mathematichs and Sciene Study, Indonesia ranked 50<sup>th</sup> of 53 countries on scientific literacy (National Center for Educatio Statistics, 2017). This result shows that the critical thinking skills of Indonesian students is low. One of the main problem is the less optimal approach or model learning used by teacher. Therefore, we conducted this study to investigate the effect of socio-scientific issues learning approaches on problem-solving learning model toward improving the critical thinking skills of The Islamic junior high public school students on global warming issue.

The novelty in this study is use of socio-scientific issues learning approaches that integrated with problem-solving learning model. Also, we use a local socio-scientific issue arround student residence. The students are expected to involved in discussion actively and train the critical thinking skills because the problem because the problems presented are very closely related to the daily lives of students. Therefore, this study is important to be conducted so the problem of the low critical thinking ability of Indonesian students can be improved.

## METHODS

### Research Design

This research used a quasi-experimental study with a nonequivalent control group research design (Cook & Campbell, 1979). The subjects in this study were students of class VII Madrasah Tsanawiyah (MTs) in Sukabumi Regency from three classes selected without randomization, where one class became the treatment group and another class became the comparison class. The illustration of the design of this study is shown in Table 1. The sampling technique used is a purposing sampling with research sample that is class VII C as the experimental class and class VII B as a control class (Sugiono, 2013).

**Table 1**  
Illustration of Research Design

	Pretest	Treatment	Posttest
Experiment Class	Ox	X <sub>1</sub>	Oy
Control Class	Ox	X <sub>2</sub>	Oy

Note:

- X<sub>1</sub> : Learning with SSI learning approach
- X<sub>2</sub> : Learning with direct instruction learning

### Data Collection

The data collection technique in this study used research instruments in the form of tests and questionnaires as shown in Table 2. The test was conducted to measure students' critical thinking skills while a questionnaire was used to determine students' interests and responses to the application of the socio-scientific issues learning approach. The research instrument used in this study was a critical thinking ability test in the form of 9 question essays and 10 student responses to the application of the socio-scientific issues learning approach.

**Table 2**

Data collection technique

No.	Data	Source	Instrument	Data collection technique
1	Students' critical thinking skills	Test	Test of students' critical thinking skills	Conducted before and after learning
2	Questionnaires of students' response toward socio-scientific learning approach	Questionnaires	The learning questionnaires sheet of socio-scientific learning approach	Conducted after learning is complete. Students fill out a questionnaire sheet with a Likert scale

The critical thinking skills used in this study are 5 indicators as shown in [Table 3](#), namely focusing questions, analyzing questions, asking and answering questions about an explanation, considering whether the source can be trusted or not, and observing and considering an observation report. The questionnaires of students' response toward socio-scientific learning approach used in this study are 4 aspects as shown in [Table 4](#), namely interest in learning using socio-scientific issues learning approach, motivation in following the learning process and in critical thinking, activeness of students in learning, and understanding of the material being taught.

**Table 3**

Critical Thinking Ability Indicators

No.	Critical Thinking Ability Indicators	Test Number
1	Focusing questions	1,2
2	Analyzing questions	3
3	Asking and answering questions about an explanation	4,5
4	Considering whether the source can be trusted or not	6,7
5	Observing and considering an observation report	8,9

Source: Ennis (2011)

**Table 4**

Participant Response Questionnaire

No.	Observed Aspects	Test Number
1	Interest in learning using socio-scientific issues learning approach	1,3,5,7,9
2	Motivation in following the learning process and in critical thinking	2,4,10
3	Activeness of students in learning	6
4	Understanding of the material being taught	8

## Procedure

The procedure in this study was performed based on the following steps: 1). Preparation: before the study was conducted by carrying out observation of learning model and approach used by teacher at school, then research experiment and judgement were made, trials, analyzed of instrument respectively. 2). Implementation: pretest, learning in the experiment and control class, and posttest were conducted. Also, data collection was done in this step. 3). Completion: collected data from previous step was analyzed and discussed in this step. At the end the result of this study was concluded.

## Data analysis technique

The quantitative data in this study was collected in the form of initial test scores and final test of students' critical thinking skills. Initial test score data and In the final test, the normalized N-Gain calculation is performed using the formula of Hake (Meltzer, 2002). The difference in

the test results of students' critical thinking skills was tested by using statistical tests. Data analysis using the statistic test begins with the prerequisite analysis test, namely the normality test and homogeneity tests then continued with hypothesis testing. The hypothesis test is performed using the t-test.



**Figure 1**  
Research procedure

## RESULTS AND DISCUSSION

Based on the prerequisite test that the research data is normally distributed and homogeneous so that the hypothesis test was done using the t-test. The result of statistic test showed the significance value of the difference in the N-gain value of critical thinking skills in both sample classes. Hypothesis testing in this study used a value (t) of 95% (0.05) with  $db = n_1 + n_2 - 2 = 25 + 26 - 2 = 49$ , the t table is obtained using the function (TINV) in microsoft excel. Based on the results of the calculation, the value of  $t_{count} = 3,800 > t_{table} = 2,009$  means that  $H_0$  is rejected and  $H_1$  is accepted. It means that socio-scientific issues learning approach on problem solving learning model has a significant effect on students' critical thinking skills. The results of increasing students' critical thinking skills are obtained from the difference between the posttest and pretest scores during learning in each sample class as shown in Tabel 5 while the acquisition of pretest and posttest scores on each indicator can be seen in Table 6.

**Table 5**  
Recapitulation of Calculation of Critical Thinking Ability Test Value

Class	Average of Pretest	Average of Posttest	Average of N-gain	Criteria
Experiment	42.97	65.16	0.38	Medium
Control	34.74	50.87	0.24	Low

In addition, overall the average N-gain value in the experimental class according to Hake (Meltzer, 2002) is included in the medium criteria. This shows that the increase in students' critical thinking skills did not change significantly. Zeidler et al. (2005) and Nuangchalerm (2010) state that the socio-scientific issues approach is a strategy that aims to stimulate intellectual, moral and ethical development, and awareness about the relationship between science and social life. This stimulation causes an increase in critical thinking skills. Besides, the use of socio-scientific issues also affects the improvement of students' critical thinking skills in the experimental class.

Socio-scientific issues approach as a whole can train students' critical thinking skills by analyzing a problem that exists in the lives of students. This problem is local in nature so that students are more active in seeking and processing information themselves. Then students analyze the positive and negative impacts so that they are able to find solutions and make decisions from the information found by students.

Increasing critical thinking skills during learning using the socio-scientific issues learning approach is also described by Callahan (2009) and Zeidler et al. (2009) stated that the target of socio scientific issues-based science abilities that can be developed is the ability to think critically and think creatively which shows the level of a person's literacy development in terms of collecting and analyzing information or data from various sources. By learning to use issues,

especially local issues, it encourages students to be actively involved in the process of seeking information, analyzing, and finding solutions and taking action. This is due to the emotional involvement of students with social problems that occur in the environment around students.

**Table 6**

Obtaining N-gain for Every Indicator of Critical Thinking Ability in Experiment Class and Control Class

Indicators of Critical Thinking Ability	Experiment Class		Control Class		Difference in N-gain
	N-gain	Criteria	N-gain	Criteria	
Focusing Questions	0.34	Medium	0.31	Medium	0.03
Analyzing Questions	0.64	Medium	0.63	Medium	0.01
Ask and answer questions about an explanation	0.51	Medium	0.28	Medium	0.23
Consider whether the source can be trusted or not	0.24	Medium	0.17	Medium	0.07
Observe and consider an observation report	0.37	Medium	0.14	Medium	0.23

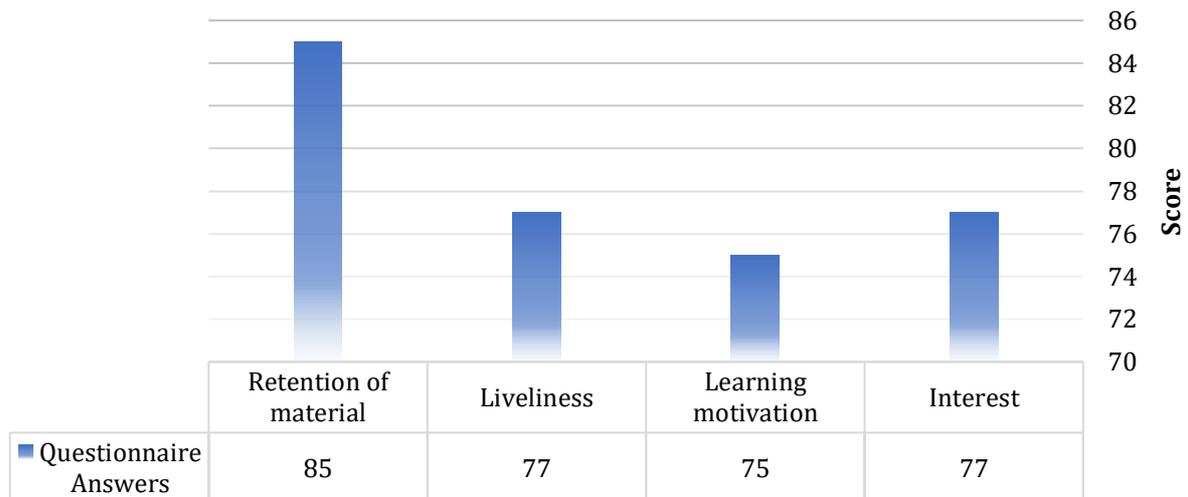
In Table 6 shows that each indicator of students' critical thinking skills in the experimental class has increased N-gain value of each indicator. The indicator that has the highest value is analyzing the question of 0.64, while the one with the lowest N-gain is the indicator of critical thinking ability in considering whether the source can be trusted or not at 0.24. This increase due to the use of local socio-scientific issues. The use of these issues makes students more active in finding and processing their information then students analyze the positive and negative impacts so they can find solutions and make decisions from information found by students. Increasing the ability to think critically in analyzing higher-level questions is in line with the benefits of learning socio-scientific issues proposed by Zeidler et al. (2005) that learning socio-scientific issues can improve critical thinking skills which includes analyzing, making conclusions, provide explanation, evaluate, interpret, and conduct self-regulation.

In addition, this increase is influenced by the stimulation arising from the socio-scientific issues learning process in the form of a learning framework namely 1) the category of reasonable differences of opinion; 2) good communication or important traits to be involved in reasonable disagreements; 3) narrative ideas and experiences that can best explain the difference of opinion (Gutierrez, 2015). In the control class, differences in classroom situations and teacher-center learning models make the increase in critical thinking skills low. Students tend to be passive and dependent in the learning process so that knowledge construction is very count on the teacher. The learning process like this affects the classroom situation, the interest of students in the learning process becomes low so that the learning objectives are difficult to be achieved (Ristanto et al., 2020). In addition, this condition can also affect the results of increasing critical thinking skills in each indicator.

As presented in Table 6 if seen from the overall N-gain value, the increase in critical thinking skills in the control class is included in the low criteria. This indicates that the increase in critical thinking skills in the experimental class is greater than the control class. Learning in the control class is very limited because students cannot explore their knowledge actively and independently, learning is done only in groups and discussions. Such learning conditions do not require students to think comprehensively, so they do not practice critical thinking skills as in the experimental class with the Socioscientific Issues approach. Meanwhile, students' responses to the socio-scientific issues approach based on questionnaire indicators can be seen clearly in Figure 2.

Overall, students' responses to the Socioscientific Issues learning approach include the agreed criteria based on Sugiyono (2013). This shows that students feel interested to the

learning atmosphere with a learning approach socio-scientific issues, because during the learning process students are given the opportunity to discuss, make observations, formulate problems, analyze problems, seek information to communicate the results of the discussion. Cross et al. (2008) stated that discussion in class is very effective in several ways, including in expressing ideas or opinions. This is one of the students' interests in socio-scientific issues learning process. All of these activities are supported by the use of local issues that exist in the environment around students so that learning becomes more interesting and students arguments can be more exploring. In this way, students feel excited and ultimately interested in socio-scientific issues learning process. This supports the results of this data analysis which shows that there is an influence of the socio-scientific issues learning approach on students' critical thinking skills.



**Figure 2**  
Graph Percentage of Questionnaire Answers for Each Indicator

The critical thinking skills are needed by students in the 21st century because one of the critical elements for creating 21st century skill is emphasize learning skill (Miharja, et al., 2019). Learning skill comprise three broad categories of skills. There are information and communication of skills, thinking and problem-solving skills, and interpersonal and self-directional skills (Partnership 21st Century Skill, 2002). Learning skills, especially the critical thinking skills can be trained by using socio-scientific issues learning approach in classroom.

In train the critical thinking skills, there are some factors that can influence thinking skills and behavior of students to support environmental sustainability (Harahap et al., 2020; Ristanto et al., 2021). The first is culture that can construct students' way of thinking. In a good culture that always train the critical thinking skills such as in home, schools, or surrounding environment, student will get used to solve problem by using steps of the critical thinking. As described by Indah and Kusuma (2016) that the largest portion of the factors that influence the critical thinking are given to the cultural factor. The second is use of learning approach and model that can train the critical thinking skills of students (Hamdani et al., 2020; Ristanto et al., 2020). Socio-scientific issues learning approach can train the critical thinking skills of students. This is because use of socio-scientific issues such as environmental issues that occur in surrounding us can stimulate students for argumentating, critical thinking, and grow awareness toward environmental sustainability. This is supported by Susilawati (2020) states that socio-scientific issues can improve environmental awareness.

This research can be implemented by teachers especially during pandemic of COVID-19 by using COVID-19 issues such as origin, transmission, and disease caused by SARS-Cov-2, virus that cause of COVID-19. Besides that vaccine issues can be applied as a socio-scientific issues

that arise in public with all the controversy. This moment can stimulate students' argumentation and critical thinking skills because issues used is very close with students' life.

## CONCLUSION

Based on data from research and data processing and after testing the hypothesis that socio-scientific issues learning has a significant effect on students' critical thinking skills on each indicator on the subject of global warming. The suggestions in this study are 1) in the learning process the teacher conditions all students to be actively involved in the discussion process so that all students fully can think critically; 2) this learning requires a long time to be able to train all indicators of students' critical thinking skills; 3) In addition to cognitive assessment, during the learning process, the teacher can assess the affective of students so that awareness about the scientific and social relationships of students can see.

## ACKNOWLEDGMENT

We are grateful to the school who are willing to cooperate in this research. and also to all parties who contributed to this research.

## REFERENCES

- Bosser, U., & Lindahl, M. G. (2020). Students' Use of Open-Minded Attitude and Elaborate Talk in Group Discussion and Role-Playing Debate on Socioscientific Issues. *EURASIA Journal of Mathematics, Science, and Technology Education*, 16(12). 1-13. <https://doi.org/10.29333/ejmste/9127>
- Callahan, Brendan, E. (2009). Enhancing Nature of Science Understanding, Reflective Judgment, and Argumentation through Socioscientific Issues. *Dissertation*. University of South Florida. Retrieved from <https://scholarcommons.usf.edu/cgi/viewcontent.cgi?article=2885&context=etd>
- Cook, T.D., Campbell, D.T. (1979). *Quasi-experimentation: Design & analysis issues in field settings*. Boston, MA: Houghton Mifflin.
- Cross, D., Taasobshirazi, G., Hendricks, S., & Hickey, D.T. (2008). Argumentation: A strategy for improving achievement and revealing scientific identities, *International Journal of Science Education*, 30(6), 837-861. <https://doi.org/10.1080/09500690701411567>
- Ennis, R.H. (2011). *The Nature of Critical Thinking: An Outline of Critical Thinking Dispositions and Abilities*. Retrieved from [https://education.illinois.edu/docs/default-source/faculty-documents/robert-ennis/thenatureofcriticalthinking\\_51711\\_000.pdf](https://education.illinois.edu/docs/default-source/faculty-documents/robert-ennis/thenatureofcriticalthinking_51711_000.pdf)
- Gulo, W. (2002). *Strategi Belajar Mengajar*. Jakarta: Grasindo.
- Gutierrez, & Sally, B. (2015). Integrating Socio-Scientific Issues to Enhance the Bioethical Decision-Making Skills of High School Students, *International Education Studies*. 8(1), 142-149. <https://doi.org/10.5539/ies.v8n1p142>
- Hamdani, M., Prayitno, B. A., & Karyanto, P. (2020). Demonstration and experiment on archaeobacteria and eubacteria: effectiveness for cognitive learning outcomes (CLO) based on critical thinking skill. *Biosfer: Jurnal Pendidikan Biologi*, 13(1), 75 - 85. <https://doi.org/10.21009/biosferjpb.v13n1.75-85>
- Harahap, L. J., Ristanto, R. H., & Komala, R. (2020). Getting critical thinking about ecosystem: How impact and responses of students about the CirGi learning model?. *Biosfer: Jurnal Pendidikan Biologi*, 13(1), 86-100. <https://doi.org/10.21009/biosferjpb.v13n1.86-100>
- Indah, R. N., & Kusuma, A. H. (2016). Factors Affecting The Development of Critical Thinking of Indonesian Learners of English Language. *Journal of Humanities and Social Science*, 21(6), 86-94. <http://repository.uin-malang.ac.id/536/>
- Lathifah, Anis Samrotul & Susilo, Herawati. (2015). Penerapan Pembelajaran Socioscientific Issues melalui Metode Simposium berbasis Lesson Study untuk Meningkatkan

- Kemampuan Berpikir Kritis Mahasiswa pada Mata Kuliah Biologi Umum. *Prosiding Seminar Nasional Pendidikan Biologi 2015. Th III*, 9-19.
- Meltzer, D. E. (2002). The relationship between mathematics preparation and conceptual learning gains in physics: A possible "hidden variable" in diagnostic pretest scores. *American Journal of Physics*, 70(12), 1259–1268. <https://doi.org/10.1119/1.1514215>
- Miharja, F. J., Hindun, I., & Fauzi, A. (2019). Critical thinking, metacognitive skills, and cognitive learning outcomes: A correlation study in genetic studies. *Biosfer: Jurnal Pendidikan Biologi*, 12(2), 135-143. <https://doi.org/10.21009/biosferjpb.v12n2.135-143>
- National Center for Education Statistics. (2017). *Highlights From TIMSS and TIMSS Advanced 2015*.
- Nuangchalerm, P. (2010). Engaging students to perceive nature of science through socioscientific issues-based instruction. *European Journal of Social Sciences*, 13 (1), 34–37.
- OECD. (2015). *PISA 2015 Result in Focus*.
- Partnership for 21<sup>st</sup> century Skill. (2002). *Learning for the 21<sup>st</sup> century. A Report and MILE Guide for 21<sup>st</sup> century skills*. Retrieved from <https://eric.ed.gov/?id=ED480035>
- Ristanto, R. H., Miarsyah, M., Muharomah, D. R., Astuti, T. A., & Aini, S. Prihatin., AI (2019). Light-Board: simple media to learn photosynthesis concepts. *International Journal of Advanced Trends in Computer Science and Engineering*, 9(1), 299-303. <https://doi.org/10.30534/ijatcse/2020/45912020>
- Ristanto, R. H., Djamahar, R., Heryanti, E., & Ichsan, I. Z. (2020). Enhancing students' biology-critical thinking skill through circ-based scientific approach (cirsa). *Universal Journal of Educational Research*, 8(4A), 1-8. Retrieved from [http://www.hrpub.org/journals/article\\_info.php?aid=9087](http://www.hrpub.org/journals/article_info.php?aid=9087)
- Ristanto, R.H, Sabrina, A., & Komala, R. (2021). Critical Thinking Skills of Environmental Changes: A Biological Instruction Using Guided Discovery Learning-Argument Mapping (GDL-AM). *Participatory Educational Research*, 9(1), 173-191. <https://doi.org/10.17275/per.22.10.9.1>
- Sanjaya, Wina. (2013). *Strategi Pembelajaran*. Jakarta: Kencana Prenada Media Group.
- Subiantoro, A. W., Handziko, R. C., & Wibowo, Y. (2021). A narrative inquiry of socio-scientific issues-based e-learning development in biology to promote student health literacy . *Biosfer: Jurnal Pendidikan Biologi*, 14(1), 132-143. <https://doi.org/10.21009/biosferjpb.20373>
- Subiantoro, A. W. (2011). Socio-Scientific Issues and Its Potency on Biology Instruction for Character Edu- Cation in Indonesia. *Proceeding of The 4th Inter- National Conference on Science and Mathematics Education. Malaysia: SEAMEO RECSAM21*(2), 136–44. <https://doi:10.17977/jip.v21i2.8367>.
- Subiantoro, A.W., Paidi, & Ariyanti, N. A. (2012). Lesson Study dalam Perkuliahan Biologi Umum dengan Socioscientific Issues-based Instruction untuk Character Building. *Makalah pada Seminar Nasional IX Pendidikan Biologi FKIP UNS*.
- Subiantoro, A. W., Ariyanti, N. A., & Sulisty. (2013). Pembelajaran materi ekosistem dengan socio-scientific issues dan pengaruhnya terhadap reflective judgment siswa. *Jurnal Pendidikan IPA Indonesia*, 2(1), 41–47. <https://journal.unnes.ac.id/nju/index.php/jpii/article/view/2508>
- Sudiarta I.G. (2009). Pengembangan pembelajara berpendekatan tematik berorientasi pemecahan masalah matematika terbuka untuk mengembangkan kompetensi berpiki divergen, kritis, dan kreatif. *Jurnal Pendidikandan Pengajaran UNDIKSHA*. 2 (4): 373-392.
- Sugiyono. (2013). *Metode Penelitian Pendidikan*. Bandung: Penerbit Alfabeta.
- Suparini, S., Rusdi, R., & Ristanto, R. H. (2020). Guided discovery-blended learning (GDBL) for critical thinking skill empowerment: A learning strategy in human excretory system. *Biosfer: Jurnal Pendidikan Biologi*, 13(2), 266–279.

<https://doi.org/10.21009/biosferjpb.v13n2.266-279>

- Susilawati, Aznam, N., Paidi, & Irwanto, I. (2020). Socio-scientific issues as a vehicle to promote soft skills and environmental awareness. *European Journal of Educational Research*, 10(1), 161–174. <https://doi.org/10.12973/EU-JER.10.1.161>
- Wang, H. H., Hong, Z. R., Liu, S. C., & Lin, H. S. (2018). The impact of socio-scientific issue discussions on student environmentalism. *Eurasia Journal of Mathematics, Science and Technology Education*, 14(12). <https://doi.org/10.29333/ejmste/95134>
- Zeidler, D. L., Sadler, T D., Michael, L., Simmons, & Elaine, V. H. (2005). Beyond STS: A Research-Based Framework for Socioscientific Issues Education. *Science Education*, 89(3), 357–77. <https://doi.org/10.1002/sce.20048>.
- Zeidler, D. L., Sadler, T.D., & Applebaum, S.(2009). Advancing Reflective Judgment through Socio-scientific Issues. *Journal of Research in Science Education*, 46(1), 74-101. <https://doi.org/10.1002/tea.20281>