Increasing Scientific Reasoning within Discussion of Scientific and Socioscientific Issues on Virus Topics

Nuzli Fahdia Mazfufah, Yanti Herlanti, Yuke Mardiati

Syarif Hidayatullah State Islamic University Jakarta, Jl. Ir. H. Djuanda 95, Ciputat, Indonesia

Corresponding e-mail: yantiherlanti@uinjkt.ac.id

Abstract

Scientific reasoning is useful in order to solving problems in life. The discussion of socioscientific issues has potential to improve students' scientific reasoning. This research aimed to determine the use of discussion of virus issues in scientific and socioscientific to improving students' scientific reasoning. This research used experimental method with two group pretest posttest design. Sample was students of class X SMAN 87 Jakarta in the academic year 2016/2017. Sample divided into experimental class 1 and experimental class 2. Each class consisted of 32 students. The learning process used two methods that are the discussion of scientific issues and socioscientific issues. The scientific reasoning abilities were excavated through the test in the form of essay. The results showed discussion method of socioscientific issues is better in improving students' scientific reasoning abilities than discussion method of scientific issue.

Keywords: scientific issues, socioscientific issues, scientific reasoning

1 INTRODUCTION

The 21st century demands many skills, one of it is thinking skill. (Alismail & McGuire: 2015, 150). The way of thinking is the ability of an individual in solving various problems. The thinking skill in solving problems is part of good reasoning ability. (Suriasumantri: 2005, 39). Good reasoning ability can be used by humans to develop knowledge. (Suriasumantri: 2005, 39). Knowledge makes a person able to make choices, which one is right and which one is wrong and which one is good and which one is bad. (Suriasumantri: 2005, 39). The ability of scientific reasoning is useful for students to make decisions and solve problems in everyday life.

Science learning in the classroom is generally focused on practical work than to involve the students in the thinking process. (Asniar: 2016, 33). As the result, students are not given the chance to develop scientific reasoning. It is causing the low level of students' scientific reasoning ability. Research conducted in one high school in Colomadu, Central Java shows that students' scientific reasoning ability of class XI in the school, as a whole is in the category less. Students could not reach at least 50% on every aspect of scientific reasoning. (Daryani: 2016, 163)

There are several aspects that build scientific reasoning, one of it is argumentation. Scientific reasoning and argument have interrelated relationships. This is supported by one of the studies conducted on non-science students and science students showing the result that scientific reasoning ability of non-science students is higher than science students. The scientific reasoning abilities of non-science students are due to non-science students being accustomed to providing answers based on strong arguments. While most science students just choose an answer without being able to express the argument why choose it. (Asniar: 2016, 38)

A learning method that provides an opportunity to argue is a discussion. Discussions make students actively involved in learning. Teachers and students or between students with students chat and share opinions in solving problems. This method can improve the ability of scientific reasoning to get the solution of a problem. The results showed that the discussion have significant effect on the students' content knowledge, students' scientific reasoning ability, students' argumentation skill, and students' knowledge on the nature of science. (Shoulder: 2013. 143). In addition, learning through discussion also has a significant effect on students' ability of analysis thinking and moral reasoning. (Wongsri & Nuangchalerm: 2010, 240).

Discussions in science classes usually address the scientific issues and socioscientific issues. (Herlanti: 2014, 2). Scientific issues are issues that only involve the knowledge of science. The issue raised is a science issue that is considered as a collection of unresolved facts. As for socioscientific issues are defined as controversial social issues and related to science, both in concept and procedure. (Sadler: 2011, 4). The application of sociosaintific issues in the classroom involves science and social topics in society that require students to engage in dialogue, discussion and debate. (Zeidler & Nichols: 2009, 49).

Socioscientific issue is an issue that relies on science issues and social issues in society. From a science point of view, the solution for socioscientific issues involve the use of principles of science, theory, and data. (Sadler: 2011, 4). While in social terms, the solution for this issue involves various factors such as politics, economics, and ethnicity. (Sadler: 2011, 4). In the discussion, socioscientific issues tend to be studied from multiple perspectives so as to elicit different answers. (Levinson: 2015, 1204).

Virus material that is learned in grade X of Senior High School is a material which full of scientific and socioscientific issues. This is because the virus is a scientific topic that has a major impact on people's lives globally.

Some cases related to virus include HIV/AIDS. HIV/AIDS can be discussed from a scientific point of view, i.e increasing the number of cases from year to year. Data from 1987 to 1997 shows that the number of AIDS sufferers in Indonesia is no more than 45 cases. But since 2007, AIDS cases in Indonesia have soared to 2,947 cases. Until the June 2009 period this case has reached 17,699 cases. The case of HIV/AIDS can also be discussed on the basis of socioscientific issues such as controversial ideas among the community to make localization for people with HIV/AIDS.

Another issue related to virus is the spread of Zika virus. Zika virus discussed scientifically is the spread of virus from Latin America to Indonesia and has impact on pregnant women. Zika virus is also discussed socioscientific that some countries issued a controversial ban related to the departure of athletes to follow the Olympics held in Brazil.

The use of virus in the form of vaccine, in addition of containing scientific issues as part of the utilization of the virus into a vaccine, also contains socioscientfic issues. Controversy occurs when the majority of Indonesian Muslims are faced with cases of vaccines containing pork materials in the market.

This study aimed to see the increasing of students' scientific reasoning who discuss using scientific and socioscientific issues.

2 METHODS

The experiment was conducted using experimental method. The study was conducted at a SMAN Jakarta from August to September, Odd Semester of the academic year 2016/2017. The study involved 64 participants who were divided into two classes: experiment 1 and experiment 2.

Table 1. Two Group Pre-test Post-test Design

Class	Pre-test	Treatment	Post-test
Experiment (E1)	O_1	X_1	O_2
Experiment (E2)	O_1	X_2	O_2

Information:
O1: Pretest experiment class 1
O2: Posttest experiment class 2
X1: Method of discussion of socioscientific issues
X2: Discussion of scientific issues

The experimental class 1 conducts lessons by using the method of socioscientific issues discussing topics, "controversial ideas among people to make localization for people living with HIV/AIDS", "prohibitions issued by some countries related to the departure of their athletes to the Olympic Games held in a country that infected by Zika virus", and "vaccine cases containing pork is revolving in Indonesian society with majority of Moslem". As for the experimental class 2, the learning was done by using the discussion of scientific issues that raised the topic, "the increasing number of people living with HIV/AIDS from year to year", "the spread of Zika virus and the consequences for pregnant women", and "the utilization of the virus into a vaccine ".

The scientific reasoning instrument used is a test in the form of essay of 15 valid questions with a reliability level of 0.73. This study measures scientific reasoning using five reasoning patterns that consist of Class Inclusion Reasoning, Serial Ordering Reasoning, Theoretical Reasoning, Functionality Reasoning, and Probabilistic Reasoning. The distribution of scientific reasoning is shown in the following Table.

Table 2. Scientific Reasoning Patterns on Test Instruments

Scientific Reasoning Patterns	Number of Questions	Total of Questions
Class Inclusion Reasoning	1,2,3	3
Serial Ordering Reasoning	4,5	2
Theoretical Reasoning	6,7,8	3
Functionality Reasoning	9,10,11,12	4
Probabilistic Reasoning	13,14,15	3
Total	15	15

The results of the pre-test and post-test appraisal of scientific reasoning are assessed and categorized based on a scale of scientific reasoning ability categories adapted from the Anton E. Lawson Classroom Test of Scientific Reasoning. (Lawson: 2000).

Table 3. Category of Scientific Reasoning Ability

Category of scientific reasoning ability	Score
Great (Formal)	71-100
Good (Transition)	36-70
Poor (Concrete)	0-35

The calculation of the increase in reasoning is done using N-Gain based on the Meltzer formula (2002, 1260). N-Gain calculation criteria were translated according to Hake's criteria (1999, 1).

3 RESULTS AND DISCUSSION

Pre-test and post-test results are presented in Figure 1. In the figure, there is an average difference in the pre-test, the experimental class II is higher than the experimental class I, but the statistical test results show the differences are not significant (t arithmetic = 1,87 t table = 1,99). Post-test results indicate otherwise that the average of experimental one is higher than two, with significant differences (t arithmetic = 3,57 t table = 1,99). This result shows the speakers of students using socioscientific issue discussion methods better than the scientific issue.

Figure 1. The average of pre-test and post-test result

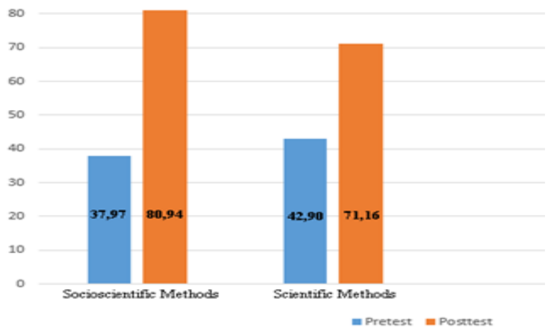


Figure 2. The average scientific reasoning for each aspect of scientific reasoning

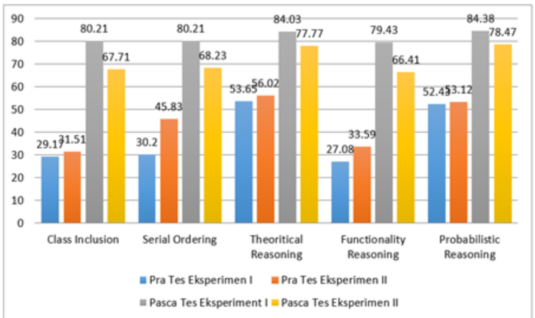


Figure 2 shows the average scientific reasoning for each aspect. The figure shows the pre-test average of almost all aspects in the experimental class II is higher than the experimental class I, but the post-test average of all aspects of critical thinking in the experimental class one is superior to that in the experimental class II.

The example of the students' answer to each aspect of reasoning can be seen in Table 4. The table presents examples of ideal answers and not ideal answers for students.

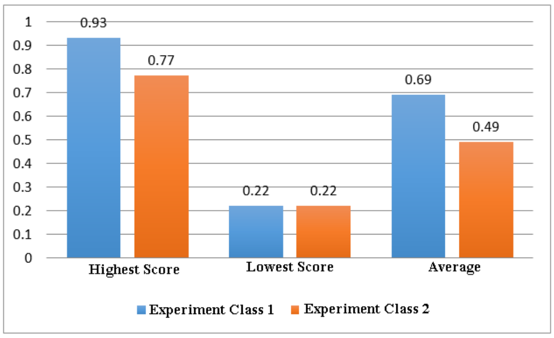
Table 4 explains that the students' answers with good reasoning can fill up the criteria that presented in the indicator. The answers with good reasoning are completed by good reasons as well. Based on the comparison in Table 4, it can be illustrated that the answer with good reasoning is compatible with the theory and has a conclusion that can be used to solve the problem. The answer with low reasoning is the answer that has no reason corresponding to the theory so it cannot produce conclusions or solutions for a problem.

Table 4. Examples of Student's Answers on Any Aspect of Scientific Reasoning

Scientific Reasoning	Indicator	Example answers with good reasoning	Example answers with poor reasoning
Class Inclusion Reasoning	Make a simple classification	Viruses can be classified by the presence or absence of the membranes or nucleocapsid and based on the creatures it attacks.	Viruses are classified into 3 groups, those are deadly and non-deadly viruses, viruses that attack animals and plants, and viruses that are round or oval.
Serial Ordering Reasoning	Sort a set of objects or data	Vaccine making can be done by stages: 1. Viral seedlings are turned off. 2. Enzyme addition as catalyst in metabolism and cell growth. 3. Viruses are separated from the medium. 4. Selecting the virus seeds that will be used as a vaccine. 5. Viruses are placed in a suitable medium and bred.	Stages of producing vaccine: 1. Viral seedlings are turned off. 2. Viruses are placed in a suitable medium and cultured. 3. Viruses are separated from the medium. 4. Enzyme addition as catalyst in metabolism and cell growth. 5. Selecting the virus seeds that will be used as a vaccine.
Theoritical Reasoning	Apply a concept or theory to analyze phenomenon	If there is mosquito that bites the HIV person and then it bites the healthy person, then the healthy person will not get HIV. Basically, HIV only attacks the human immune system that is in T lymphocytes. Mosquitoes do not have T lymphocytes so that when HIV enters the patient's blood into the mosquito's body, the virus cannot develop and over time will die.	Healthy people will suffer HIV because of mosquito bites that have bitten the previous HIV sufferer. HIV virus can be transmitted through the blood. In this case, the mosquito sucks the blood of the HIV sufferer, so when the mosquito bites the healthy person, the blood will enter the body of a healthy person. Causing a healthy person to become infected with HIV.
Functionality Reasoning	Analyzing functional relationship	Viruses that have a wrap or envelope, the infectivity will be lost at high temperatures. While viruses that do not have a wrap or envelope, will remain stable at high temperatures.	The wrap which belongs to some types of virus does not affect the infectivity of the virus.
Probabilistic Reasoning	Predicting according to phenomenon or data	A patient is diagnosed with symptoms such as, patches on the skin, weight loss without knowing the cause, swollen lymph glands, easy bruising or bleeding without cause, the body cannot stand the infection. So the patient has been infected with HIV and potentially suffering from AIDS.	Symptoms such as patches on the skin and decreased immunity indicate that the patient is suffering from DBD that caused by Dengue virus.

The N-Gain result shows experimental class I is superior than the experimental class II. However, the average category in both groups is between 0.3-0.7 and moderate.

Figure 3. N-Gain result



The number of students according to the increase in scientific reasoning category after learning can be seen in Table 5. Table 5 shows that the number of students who are in the high increase category in experimental class I is superior than experimental class II. The majority of the students in experimental class II is moderate.

Table 5. N-Gain Category

N-Gain Category	Number of Students (Person)		To tal
	Experimental class I	Experimental class II	
Low	1	1	2
Average	14	27	41
High	17	4	21
Total	32	32	64

The results show that the application method of the socioscientific issue discussion is more able to improve students' scientific reasoning abilities compared to the application method of scientific issues discussion, can be explained based on the following reasons:

The first reason socioscientific issue discussion method is more able to improve students' scientific reasoning abilities because learning using this method requires students to argue. Argument is an important element in reasoning because they are used to shape, nurture, and change a belief. Arguments on socioscientific issue discussions must be supplemented with strong data, guarantees and supporters to direct them to the formation of claims. Claims in socioscientific issue discussions can be statement which supports the issue (pro) and the statement that rejects the issue (cons).

Discussion of socioscientific issues raise controversial social issues and deal with science, both conceptually and procedure. (Sadler: 2011, 4). The application of socioscientific issue discussions in the learning process require not only one definite answer. In this discussion, students are required to bring up answers in terms of various aspects and perspectives, such as religion, politics, medical, culture, and economics.

The second reason is socioscientific issue discussion methods more able to improve students' scientific reasoning abilities is because excavation arguments from various perspectives require students to perform cognitive processes involving logic and analysis. Logic and analysis are the basis of reasoning. (Suriasumantri: 2005, 43). The process of analysis in the discussion takes place when students investigate the arguments made by linking the argument with the concept or theory being studied. The process of investigation is done to obtain a strong argument.

Discussions using scientific issues require only answers according to facts and concepts. In classroom learning, the method of discussion of scientific issues is less evoking the participation of discussion participants because the issues raised are science issues that are impressed as a collection of unresolved facts. This is the thing that distinguishes the discussion of scientific issues with the discussion of socioscientific issues that require argumentative answers from various aspects and points of view. The nature of the controversy in a socioscientific issue discussion will make students learn about the content, process, and nature of science and technology, and also develop students' views on cognitive, social, political, moral, and ethical. In the discussions of socioscientific issues, student interest is also increasing because the issues raised are issues that are warm in everyday life.

Data achievement of scientific reasoning pattern shows that in the experimental class 1 and experimental class 2, the probabilistic reasoning aspect has the highest value, while the functionality reasoning aspect has the lowest value. Probabilistic reasoning is a scientific reasoning ability that gets the highest percentage of achievement. The characteristic of this reasoning pattern is that students are required to be able to recognize the facts of an existing phenomenon. In this case, in general, students have been able to predict based on data. This is clearly reflected from the learning process in the experimental class 1 using the socioscientific issue discussion method. The use of this method requires students to predict the issues raised, so that students can declare their position on the issue. Questions such as, "do you agree with the use of vaccine which contains pork in the community", directing students to do the predicting process.

The pattern of probabilistic reasoning is also reflected in the discussion phase of scientific issues. This is possible because during the discussion process, students have been accustomed to make predictions related to the topics raised. For example, when discussing a scientific issue, a question arises, "is it possible for a person to have a viral illness resulting from the use of a vaccine?". Through this question, students who discuss using scientific issues are also trained in making predictions. Thus, in this study both experimental class 1 and experimental class 2 successfully develop probabilistic reasoning aspects in their learning process.

Functionality reasoning is a scientific reasoning ability that gets the lowest of percentage achievement in both classes. Functionality reasoning is a scientific reasoning ability that requires students to be able to analyze functional relationships. In this reasoning pattern, students are required to find the relationship between one variable with another variable. In the experimental class 2, this reasoning pattern is in enough category. This probably because the questions discussed by students on discussions of science issues are limited to C1 cognitive level and factual knowledge level. Question C1 is a question that focuses on simple memorizing levels. So that students' analyzing ability cannot be maximally explored. An example of a question raised in a scientific issue discussion is, "who discovered the virus?", "What caused Zika virus transmission?", And "how do the virus attack its host?". It is the thing that makes this pattern of reasoning in the category enough in the experimental class 2. In the experimental class 1, although the functionality reasoning gets the lowest percentage, however, it is still in the good category.

The reason that allows functionality reasoning to be at the lowest percentage in the experimental class is because in the process of socioscientific issues discussion, students are judged less able to find a functional relationship between one phenomenon with another phenomenon. It has seen from the arguments made by students, where, there are still some arguments that do not have strong evidence. An example of an argument that is not accompanied by strong evidence is, "I do not agree with the departure of athletes to a country infected with the Zika virus because it harms athletes and makes athletes carry the virus if they return to their country."

Scientific reasoning abilities are different from person to person, depending on their cognitive development and experience. In this context, the using of different methods for the two classes can make an effect on their cognitive abilities and experiences. With the using of different learning methods, it will directly distinguish the types of scientific reasoning exercises that obtained. Scientific reasoning exercises are regularly required to generate long-term effects on student achievement within the scope of scientific reasoning. Scientific reasoning exercises are needed on a regular basis in order to generate long-term effects on student achievement, particularly in terms of scientific reasoning. (Bao: 2009, 586)

4 CONCLUSIONS

Students' scientific reasoning that apply socioscientific issue discussion is higher than students who apply scientific discussion. There is no difference in the attainment of reasoning patterns between students who discuss scientific and socioscientific issues. The probabilistic reasoning pattern is more mastered by students in scientific discussions and socioscientific issues than the other patterns. The reasoning pattern of functionality reasoning is the least mastered by students in scientific discussions and socioscientific issues.

The results show that the socioscientific issue discussion method can improve students' scientific reasoning ability. Thus, the use of this method is strongly recommended to improve students' scientific reasoning abilities. In the application of socioscientific issue discussion methods, teachers should pay attention to all students who are members of the discussion because often only a few students who actively argue. It would be better if all students get the same portion in expressing their arguments verbally.

5 REFERENCES

Alismail, H. A., McGuire, P. (2015). 21st Century Standards and Curriculum: Current Research and Practice. *Journal of Education and Practice, 6*(6), 150.

Asniar. (2016). Profil Penalaran Ilmiah dan Kemampuan Berargumentasi Mahasiswa Sains dan Non-Sains. *Jurnal Penelitian dan Pembelajaran IPA, 20*, 33-38.

Bao, Lei. Cai, Tianfan. Koenig, Kathy. (2009). Learning and Scientific Reasoning, *Journal American Association for the Advancement of Science, 323*. 586.

Shoulder, C. W. (2013). Socioscientific Issues-based Instruction: An Investigation of Agriscience Students' Content Knowledge based on Student Variables. *Journal of Agricultural Education, 54*(3), 143.

Daryani, P. E. (2015). Peningkatan Kemampuan Penalaran Ilmiah melalui Model Pembelajaran Inkuiri Terbimbing pada Materi Sistem Pernapasan Manusia. *Jurnal Pendidikan Matematika dan Sains Tahun III, 2*, 163.

Herlanti, Y. (2014). *Blog Quest: Pemanfaatan Media Sosial pada Pembelajaran Sains berbasis Isu Sosiosaintifik untuk Mengembangkan Kemampuan Berargumentasi dan Literasi Sains.* Bandung: Sekolah Pascasarjana Universitas Pendidikan Indonesia, 2.

Lawson, A. E. (2000). Classroom Test of Scientific Reasoning. *Journal of Research in Science Teaching*.

Levinson, Ralph. (2015). Towards a Theoretical Framework for Teaching Controversial Socio-scientific Issues. *International Journal of Science Education, 28*(10), 1204.

Meltzer, David 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*, 1260.

Nuangchalerm, Prasart. (2010). Engaging Students to Perceive Nature of Science Through Socioscientific Issues-Based Instruction. *European Journal of Social Sciences, 13*(1).

Sadler, T. D. (2011). *Socio-scientific Issues in the Classroom*. New York: Springer Science+Bussiness Media.

Suriasumantri, J. S. (2005). *Filsafat Ilmu*. Jakarta: Pustaka Sinar Harapan.

Wongsri, P., Nuangchalerm, P. Learning outcomes between Socioscientific Issues-Based Learning and Conventional Learning Activities. *Journal of Social Sciences,* 240.