ASSESSMENT MODEL FOR CRITICAL THINKING IN LEARNING GLOBAL WARMING SCIENTIFIC APPROACH

Agus Suyatna, Undang Rosidin
Physics Education Post graduate Study Program, University of Lampung
asuyatna@yahoo.com

Abstract— Global warming may have an impact on food shortages, natural disasters, floods, economic disruption, massive migration, can even trigger a war. Learning and assessment of global warming is essential implemented to provide an understanding of the causes and impact of global warming on the life. Critical thinking assessment needed to foster the idea of solving the problem of global warming and its impact on life in the future. This study aims to: describe the students' understanding of the causes and effects of global warming for life, describing the need of critical thinking assessment, designing the critical thinking assessment on global warming learning using scientific approach that can foster the idea of solving the problem of global warming. Data were collected using a written test on the junior and senior high school students and a questionnaire to teachers of physics in Lampung province. The data analysis includes qualitative and quantitative analysis. Design assessment conducted through literature review and expert validation. The results showed: (1) the students' understanding of the causes and effects of global warming for life is still low, (2) teachers of physics require a model assessment of learning global warming using scientific approach to foster the idea of solving the problem of global warming, (3) critical thinking assessment on learning global warming using scientific approach, measure all indicators of critical thinking on every component of scientific approach using techniques and test forms adapted to the indicator.

Keywords: *assessment ,critical thinking, global warming, scientific approach*

I. INTRODUCTION

Carbon emissions continue to rise will cause the thick of greenhouse gases in the atmosphere. This layer will forward the heat coming from the sun but will retain heat in the earth's surface is called the greenhouse effect. The greenhouse effect is very much needed by all living things on earth, because without it, the planet would be very cool. However, if the gases are excessive in the atmosphere, will lead to global warming (1). One of the most critical environmental subjects of 21th century is Global warming (2). Intergovernmental Panel on Climate Change (IPCC) has concluded that most of the increase in global average temperature is most likely caused by increased concentrations of greenhouse gases due to human activities. Global warming may have an impact on food shortages, natural disasters, floods, economic disruption, massive migration, can even trigger a war (3). Rising global temperatures are expected to cause other changes such as rising sea levels, increased intensity of extreme weather phenomena, as well as changes in the amount and pattern of precipitation. The effects of global warming include agricultural output, loss of glaciers and the extinction of various animal species (2). Greenhouse gases (water vapor, carbon dioxide, methane, etc) existing in the atmosphere, trapping sunrays and making earth's atmosphere warmer. Whereas some of these gases are naturally found in the atmosphere, human activity increases the amount of particular gases (4-6). There are two main approaches to slow the increase in greenhouse gases. First, protecting trees and planting more trees. Second, reduce the production of greenhouse gases, by reduce the burning of fossil. Both ways this can be done if there is an awareness of the community about the impact of global warming.

People's knowledge about global warming is still low. This is demonstrated by the behavior and activities of the people who contributed to the thick greenhouse gases. Most of these greenhouse gases produced by animal husbandry, burning of fossil fuels in motor vehicles,

modern factories, farms, Nitrogen Oxide (NO) from fertilizers, and the gases used in refrigerators and air conditioners (CFC), as well as plants electricity. The destruction of forests which should serve as storage of CO_2 is also a contributor to greenhouse gases because trees that die will release the CO_2 stored in their tissues into the atmosphere. Forest fires are also the largest contributor to greenhouse gases in Indonesia.

The public's understanding of the causes of global warming and its impact on life and the environment is very important. An understanding of this is expected to be able to form a disapproval of the behavior that can lead to global warming and foster the ideas to solving the impact of global warming. Therefore, people need to be educated about the causes of global warming and its impact on life and the environment. Learning communities can be started at high school students who are part of the community. As students are among the most trainable stratums of the society, it is essential to discover their knowledge and perception of greenhouse effect to prepare the best kind of educational program for them (7).

One of the educational efforts that can be done is applying critical thinking assessment on learning the scientific approach. Critical thinking assessment needed to foster the idea of solving the problem of global warming and its impact on life in the future. Critical thinking in very simply stated, the ability to analyze and evaluate information. Critical thinkers raise vital questions and problems, formulate them clearly, gather and assess relevant information, use abstract ideas, think open-mindedly, and communicate effectively with others. Critical thinking is an important and necessary skill because it can help you deal with mental and spiritual questions, and it can be used to evaluate people, policies, and institutions, thereby avoiding social problems (8). They are involved in dialog, debate, writing, and problem solving," as well as higher-order thinking, such as analysis, synthesis, and evaluation. The encouragement of critical thinking can be accomplished in any content area by modification of lectures and the incorporation of simple active learning techniques (9). Indicators of critical thinking skills are the skill of asking and answering questions, consider whether the source is reliable or not, identifying terms and consideration of a definition, determines the action to be taken, and the skills to make a conclusion (10). This indicator will be used to design assessment of global warming with a scientific approach

Assessments have various purposes such as assessment for learning, assessment of learning and assessment to learning. To assess the critical thinking skills needed authentic assessment. Authentic assessment is defined as a real assessment. Which measures the ability of students from all aspects. Authentic assessment is defined as an actual vote. It is necessary for assessment using a variety of techniques. A variety of assessment methods should be able to measure all aspects of a students knows and the students did. Authentic assessment based on scientific literacy is a form of assessment of real, meaningful for the students, are able to develop high-level thinking skills and scientific literacy containing dimensions (concepts, processes, and context) (11). Development of scientific literacy assessment instrument is based on an understanding of the concepts and methods of science, technology and the impact of science on the environment (12). The essence of this form of assessment is that the assessment is based on several sources. Some things that clearly characterize the application of authentic assessment is to measure all aspects of learning, including the process, performance and product (13). Benefits of using authentic assessment, as stated is as follows. First, the use of authentic assessment allows direct measurement of the performance of students. Second, authentic assessment give an opportunity to the students to construct learning results. Third, authentic assessment allows the integration of the activities of teaching, learning and assessment activities into one integrated package. Fourth, authentic assessment gives students the chance to show the results of their study, work performance, in a way that is considered the most (11).

Good planning should also be applied in the assessment activities that are part of the learning activities. Steps to be taken in the development of authentic assessment in global warming learning, which cover three aspects: (1) the assessment of the attitude that includes self-assessment techniques and journals; (2) an assessment of knowledge using written test with a form of multiple choice questions and essay; (3) The skills assessment includes an assessment of performance, project, and portfolio. Valuation techniques are selected according to indicators of critical thinking on global warming learning using scientific approach.

This study aims to: describe the students' understanding of the causes and effects of global warming for life, describing the need of critical thinking assessment, designing the critical thinking

assessment on global warming learning using scientific approach that can foster the idea of solving the problem of global warming impact.

II. RESEARCH METHOD

The sample consisted of teachers and students. Sample of students taken from 11 senior high school and 7 junior high school spread over the district in the Province of Lampung. Students who become the sample are students who have studied the topic of global warming and which have not. Details about the sample presented in Table 1. The total sample of teachers as many as 15 people become from 3 senior high school.

Table 1. THE BACKGROUND OF THE STUDENT SAMPLE

School and grade	Already studying global warming	N
Senior High School grade 11	yes	196
Senior High School grade 10	no	126
Junior High School grade 8	yes	165
Junior High School grade 7	no	86
Total		573

Data were collected using a written test about global warming knowledge in the form of an objective test consisting of 15 questions. Each question has three choices, true, false, and do not know. Before using, the instruments validity and reliability tested first. Data were analyzed using independent sample t-test, one way ANOVA, and multiple comparison.

Data collected from the teachers using questioner about how teachers teach global warming, teaching problem, and the need for teachers to global warming learning program. This data was analyzed qualitatively.

III. RESULTS AND DISCUSSION

A. Results

The results of the written test the understanding of global warming are presented in Table 2. Knowledge about global warming of student in Lampung Province was low. The average of score 3.6 of 10 scale. The average student only able to answer questions correctly as much as 36%. The highest average score obtained by the student of grade 11 who have learned about global warming.

Table 2. STUDENT SCORE OF GLOBAL WARMING KNOWLEDGE

School and level	Already studying global warming	N	average
Senior High School grade 11	yes	196	4.1
Senior High School grade 10	no	126	3.6
Junior High School grade 8	yes	165	3.5
Junior High School grade 7	no	86	3.2
		Average	3.6

The learning experience of global warming influence have effect on test scores. This is indicated by one-way ANOVA test results, there was significant difference ($p = 0.000 < 0.05$) in scores obtained knowledge of global warming.

The results of a further test for the average difference in test results between grade and learning experiences of global warming are presented in Table 3. Average scores were significantly different that students grade 11 with grade 10, grade 8, and grade 7. otherwise there

was no significant difference. It shows that global warming learning at the senior high school make differences in learning outcomes, while at the junior high school level is not.

Table 3. . MULTIPLE COMPARISONS OF STUDENT

(I) Class	(J) Class	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
2	1	-.4674*	.16333	**.023**	-.8883	-.0465
	3	.1254	.15113	.840	-.2640	.5148
	4	.4194	.18502	.107	-.0573	.8961
1	2	.4674*	.16333	**.023**	.0465	.8883
	3	.5928*	.16923	**.003**	.1568	1.0289
	4	.8868*	.20008	**.000**	.3713	1.4023
3	2	-.1254	.15113	.840	-.5148	.2640
	1	-.5928*	.16923	**.003**	-1.0289	-.1568
	4	.2940	.19024	.411	-.1962	.7842
4	2	-.4194	.18502	.107	-.8961	.0573
	1	-.8868*	.20008	**.000**	-1.4023	-.3713
	3	-.2940	.19024	.411	-.7842	.1962

Note:

*. The mean difference is significant at the 0.05 level.

1. Senior High School grade 11, already studying global warming
2. Senior High School grade 10, global warming has not learned
3. Junior High School grade 8, already studying global warming
4. Junior High School grade 7, global warming has not learned

Further testing is done to determine the effect of gender differences and interaction between the learning experience by gender using Two Way ANOVA. The test results showed no difference in learning outcomes due to differences in gender and no interaction between the learning experience of global warming by gender (Table 4).

Table 4. STUDENT TESTS OF BETWEEN-SUBJECTS EFFECTS

Dependent Variable: Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	49.572[a]	7	7.082	3.461	.001
Intercept	6560.369	1	6560.369	3206.303	.000
Learning experience	37.582	3	12.527	6.123	.000
gender	.634	1	.634	.310	.578
Learning experience * gender	3.518	3	1.173	.573	.633
Error	1156.038	565	2.046		
Total	8848.530	573			
Corrected Total	1205.610	572			

a. R Squared = .041 (Adjusted R Squared = .029)

B. Discussion

From the first question, about global warming is a natural event that there are 68% of students answered that the events of global warming is not a natural event means that human intervention in it. Question number 2 and 3 are questions to dig information about gases triggers the greenhouse effect, 23% of students confirmed that hydrogen, helium and neon are greenhouse gases and 13% stated that animals such as cows produce greenhouse gases. It shows most students do not understand the gases triggers the greenhouse effect. Question 7 regarding ozone obtained information that 81% of students believe that the holes in the ozone layer of the earth will increase the greenhouse effect, this is a misconception of the greenhouse effect. Question number 14 regarding the result of the greenhouse effect, as many as 58% of students stated skin cancers are caused by the greenhouse effect, in fact, skin cancer is caused by depletion of the ozone layer.

Based on the results of tests analysis and interviews with students, it can be seen the following matters. Student understanding on global warming can be grouped into three part: causes, impacts and solutions of global warming. Among the three sections, most do not understand is the cause and determine the solution. They are generally difficult to link the causes, impacts and solutions.

Students generally know the cause of global warming associated with the increase in the average temperature of the Earth's surface caused by rising greenhouse gas emissions. Greenhouse gases cause a phenomenon called the greenhouse effect. In general, students can give the analogy of the greenhouse effect that they had experienced being in a closed car that is park under the scorching heat of the sun and feel the temperature on the car was very hot, but they were not able to explain exactly why it can happen.

Greenhouse gas emissions considered dangerous that should be controlled are: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), O3, CCL2F2, CCl2F2, and sulfur hexafluoride (SF6). From the test results there are a variety of student responses regarding greenhouse gases are considered dangerous. From the students' responses show that students do not understand precisely gases triggers the greenhouse effect.

Students understand that the greenhouse effect will have an impact on global warming that will be followed by climate change, such as increased rainfall in some parts of the world, causing flood and erosion. Meanwhile, in the other hemisphere will dry season due to the temperature rise, but the students have not been able to explain exactly how the greenhouse effect affects climate change.

Most students concerned to existence of global warming. Various efforts are known by students to overcome the impact of global warming include reforestation and reducing air pollution. They do not know that simple act such as: walking or go to school by bike, turn off the lights after they finish studying, saving paper consumption, and others can reduce greenhouse gas contribution.

These findings were not different from the results of research to Iranian. The study showed high percentages of the students believed that if the greenhouse effect gets bigger “the Earth will get hotter”, “there will be changes in the world’s weather” and “polar ice will melt”. These findings together with students’ low level cognitive scores and the fact that students were not able to describe greenhouse effect correctly and completely indicate that students know some points about global warming but their knowledge is not deep-seated. Despite of assuming “holes in the ozone layer” as a cause of greenhouse effect by most of the students, near the same percentage of the students were aware of the fact that too much carbon dioxide and chlorofluorocarbons are causes of global warming. The students awareness about the causes of the greenhouse effect. While more than two third of the students knew “not using cars so much” and “planting more trees” are cures for global warming, about the same percentage of the students accepted this wrong idea that “using unleaded petrol is a way to reduce greenhouse effect”, therefore students’ knowledge about cures for greenhouse effect is not reliable too (7).

The results of the classroom observation indicate the learning process is centered on the teacher, the students tend to be passive in learning. The learning process tends to abstract, the teacher has not optimize the use of instructional media. Media used only pictures that are not attractive. Teachers have no implement a scientific approach in the learning process, as emphasized in the curriculum. From needs analysis questionnaire obtained information that the

teacher wanted a model of learning, assessment models, and various media to study global warming.

Based on the results of a literature review prepared an assessment models to foster critical thinking skills in understanding of global warming and looking for ideas to solving the impact of global warming as presented in Figure 1. There are five stages of global warming learning to cultivate critical thinking skills. The stages of learning global warming are as follow. Observer, to observed the phenomenon of global warming that there are around students. Questioning, asking questions about the causes of global warming phenomenon. Explore, conducting experiments to determine the relationship between the phenomenon of global warming and its causes. Infere, determine the factors that cause global warming and looking for ideas to reduce greenhouse gases. Communicate, convey ideas and attitudes toward behavior that causes global warming.

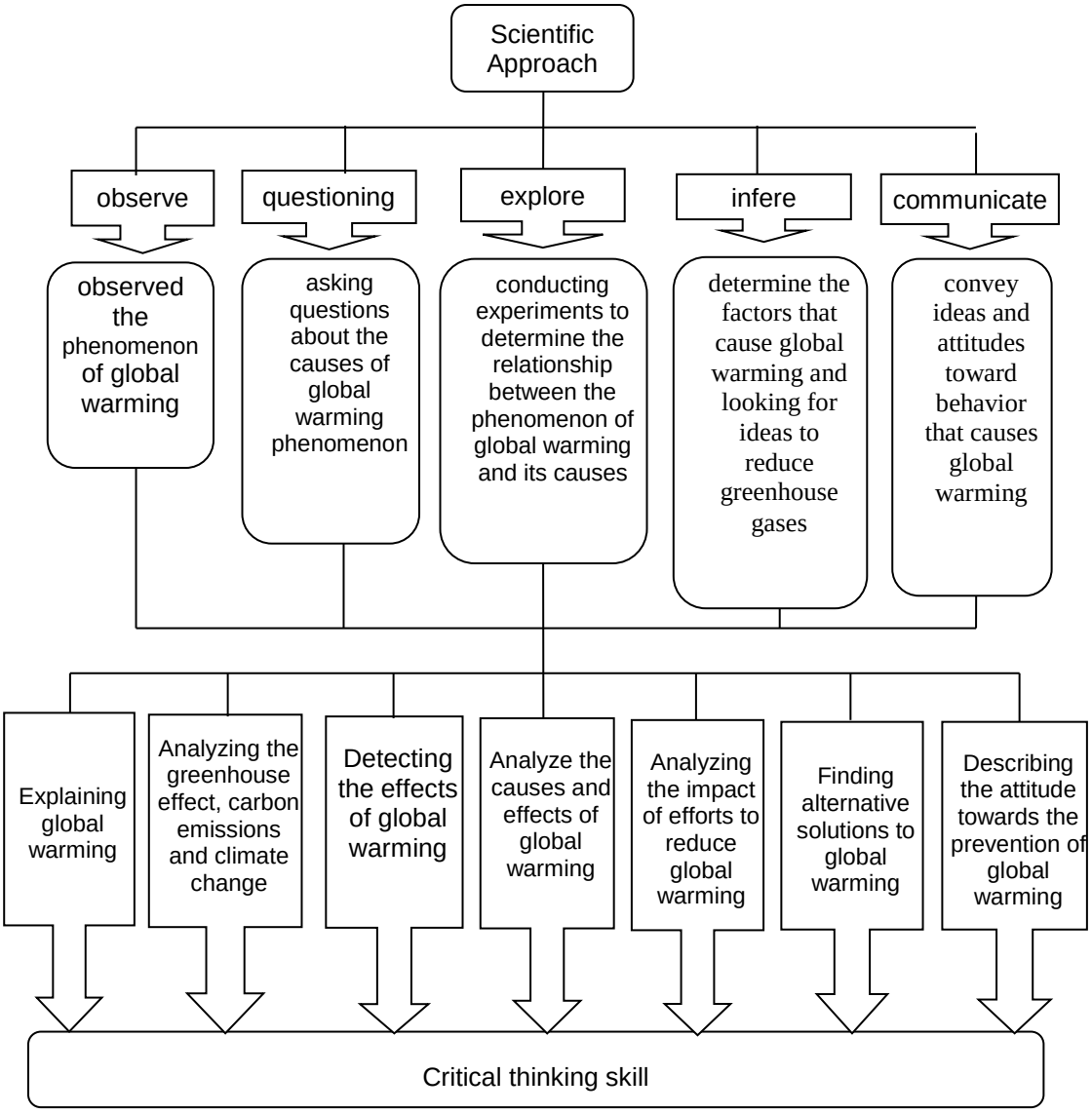

Figure 1. Assessment Models To Foster Critical Thinking Skills In Understanding Global Warming Looking For Ideas to Solving The Impact

At each stage of learning execute the assessment of global warming according to indicators of critical thinking using techniques and test forms adapted to the indicator. Indicators of critical thinking on global warming that are explaining global warming, analyzing the greenhouse effect, carbon emissions and climate change, detecting the effects of global warming, analyze the

causes and effects of global warming, analyzing the impact of efforts to reduce global warming, finding alternative solutions to global warming, describing the attitude towards the prevention of global warming.

IV. IV. CONCLUSSION AND RECOMENDATION

The results showed: (1) the students' understanding of the causes and effects of global warming for life is still low. There is a difference between knowledge of senior high school students who are studying global warming with no learning, but in junior high school students no difference. There is no difference in learning outcomes due to differences in gender and no interaction between the learning experience of global warming by gender, (2) teachers of physics require a model assessment of learning global warming using scientific approach to foster the idea of solving the problem of global warming, (3) critical thinking assessment on learning global warming using scientific approach, measure all indicators of critical thinking on every component of scientific approach using techniques and test forms adapted to the indicator.

It is necessary to find the relationship between students' knowledge of the impact of global warming with their attitude toward behaviors that contribute greenhouse gases.

It is need to develop models of global warming learning and media that can foster critical thinking skills in order to obtain innovative ideas to solving global warming impact.

ACKNOWLEDGMENT

Thanks submitted to the Directorate General of Higher Education, The Ministry of Research, Technology, and Higher Education who has been financed this research

REFERENCES

[1] Wikipedia. Global Warming. Sumber: //id.wikipedia.org/wiki/pemanasan-global, accessed March 2011.

[2] Skamp K. R, Boyes E, Stanisstreet M, Global warming responses at the primary secondary interface: 1 students' beliefs and willingness to act, Australian Journal of Environmental Education, 2009;25:15-30.

[3] IPCC. *Climate change a threat to security, food and humankind* - IPCC report. (http://www.theguardian.com/environment/2014/mar/31/climate-change-threat-food-security-humankind) , accessed March April 2014.

[4] Lee O, Lester BT, Ma L, Lambert J, Jean-Baptiste M. Conceptions of greenhouse effect and global warming among elementary students from diverse languages and cultures, Journal of Geoscience Education, 2007;55(2):117-25.

[5] Marlon JR, Bartlein PJ, Carcaillet C, Gavin DG, Harrison SP, Higuera PE, Joos F, Power MJ, Prentice IC. Climate and human influences on global biomass burning over the past two millennia, Nature Geoscience 2008;1(10): 697-702.

[6] Mitchell JFB, Johns TC. On modification of global warming by sulfate aerosols. Journal of Climate, 1997;10(2):245-67.

[7] Taraneh Y, Sousan S, Mohammad RM, Seyed MS, Eddie B, Martin S, and Mirsaeed. A global warming: Knowledge and views of Iranian Students. Acta Medica Iranica, 2013; 51(3): 178-184

[8] Hatcher, D. L., & Spencer, L. A. Reasoning and Writing: From Critical Thinking to Composition. 3rd. Ed. Boston: American Press, 2005

[9] Robert D, Barbara L, Wendy W. Critical thinking framework for any discipline, International Journal of Teaching and Learning in Higher Education, 2006; 17(2): 160-166

[10] Ennis, R. H. Critical Thinking. New Jersey: Prentice-Hall, 1996.

[11] Mueller.J. The authentic assessment toolbox: Enhancing student learning through online faculty development. North Central College, 2005; 1(1): 1-7.

[12] Chiu, S. & Chang, M. The Development of Authentic Assessments to Investigate Ninth Graders Scientific Literacy. International Journal of Science and Mathematics Education, 2005; 3: 117-140.

[13] Wijayanti. Pengembangan autentik assesement berbasis proyek dengan pendekatan saintifik untuk meningkatkan keterampilan berpikir ilmiah mahasiswa, Jurnal Pendidikan IPA Indonesia, 2014; 3 (2), 102-108

[14] Duron, R., Limbach, B., & Waugh, W. Critical Thinking Framework for Any Discipline, International Journal of Theaching and Learning in Higher Education, 2006; 17(2), 160-166.