Scientific thinking skills in solving global warming problems

A Suryansyah S*, W Kastolani, L Somantri
Departement of Geography Education, Postgraduated Programme, Universitas Pendidikan Indonesia
*suryansyahade@student.upi.edu

Abstract. Scientific thinking skills are higher-order thinking skills that must be had by students in facing the era of global competition to overcome various problems. This study aims to examine students' scientific thinking skills covering aspects of logical thinking, analysis, systematic, inductive and deductive in solving problems that include defining, identifying, formulating alternative solutions and determining the best solutions in solving global warming problems. This research uses a quantitative approach as outlined in the form of a description. The subjects of the study were high school students, Bandung City, with a total of 196 people spread across nine schools. Data obtained through questionnaires, observation, literature study, and study of documentation. Data analysis techniques using data reduction, data display, and percentage. The results showed that the students' scientific thinking skills in the analysis and logical aspects were good criteria. Whereas systematic, inductive, and deductive were sufficient criteria. The development of the issue of global warming has not been implemented well. The researchers recommend that schools and teachers integrate the problem of global warming with learning, train students in studying various global warming phenomena through higher order thinking problems and problem-solving to have scientific thinking skills.

1. Introduction
Climate change as a global phenomenon is the biggest environmental challenge facing the world today. The Intergovernmental Panel on Climate Change (IPCC) states that changes in average surface temperature globally for the 2016-2035 period compared to 1986-2005 are likely to be in the range of 0.3 to 0.7°C [1]. Even the Indonesian Aeronautics and Space Agency (LAPAN) predicts that the earth's temperature is expected to increase between 1.4° -5.8°C in 2100 [2]. Whereas in general, the increase in average temperature in the Indonesian region is estimated at 0.5 - 3.92°C in 201 from the conditions of the period 1981-2010 [3]. Global warming as a result of climate change is now a broad environmental issue and not just the problem of developed countries alone. Climate change is a joint disaster because it has an impact on all countries in the world, and must be addressed by all countries.

The impact of global warming is increasingly felt in various parts of the world, including Indonesia, which is geographically very vulnerable to the effects of climate change. Changes in temperature are also felt in big cities in Indonesia. Bandung used to be famous as a flower city, which is cool and comfortable. But today it can be felt naturally that temperature changes tend to increase in line with urban development. This increase marks global warming due to the greenhouse effect. The following data is the average temperature of the Bandung city 1976 - 2017.
Global warming that occurs is inseparable from the effects of human activities, which are the determining factors for environmental problems. Education as a means of increasing environmental knowledge, has not been able to contribute to improving behavior to be more friendly to the environment. It has not been able to form environmentally friendly behaviors because teachers in ecopedagogy lack explore students to find information, analyze, and make decisions based on inquiry, so the material provided does not become behavior, and the process of finding information and analyzing is part of scientific thinking skills [4, 5].

Education has various purposes. One of them is to support the activity of saving the earth and managing the environment. Education is a strategic sector in socializing the problem of global warming to invite all levels of society to play an active role in mitigating and adapting to global warming [6,7]. Education must be involved in environmental issues that are a common problem, in order to prepare generations who care about environmental conditions, especially the global market.

Education is a driving force that has a big contribution to the progress of a nation. Education is an investment in the future that plays an important role in determining the human quality and achieving a more prosperous life for a nation [8, 9]. Education provides experiences that can change one's cognitive, behavior, and skills. Qualified human beings are always identified with mastery of science, technology, high work ethic, readiness, and skills and noble character. [10]. So that the skills in solving problems become important in creating solutions in every problem.

Problem-solving skills are one of the qualifications that must be possessed to meet the demands of the times. The progress and development of the 21st century or known as the current knowledge age requires everyone to have various skills and qualifications to equip themselves in facing the development of the globalization era. Problem-solving skills are one of the qualifications that must be possessed to meet the demands of the times. The progress and development of the 21st century or known as the current knowledge age requires everyone to have various skills and qualifications to equip themselves in facing the development of the globalization era [11, 12].

The scientific approach in the 2013 curriculum aims to train students' scientific thinking skills. The implementation of the 2013 curriculum leads to the use of a scientific approach, which is to train students' scientific thinking skills as part of their high order thinking in solving a problem. The purpose of learning with a scientific approach is to improve the ability to think at a higher level that helps students solve the problems at hand [13].

Scientific thinking is a process of logical thinking and analysis to find truth through certain patterns of thinking. Scientific thinking is the process of finding truth based on certain thoughts which are marked by two characteristics, such as being logical and analytical and using certain logic. Scientific thinking is also a combination of inductive and deductive ways of thinking [14,15]. Thinking activities to be able to think scientifically by humans contain thinking skills that are structured in a particular series [16]. Scientific thinking is a process of obtaining truth through facts on an event. After finding the facts or truths contained in an event then it is analyzed logically. So the ability to think scientifically includes the ability to think logically, systematically, analysis, deductive, and inductive in solving problems in an effort to find the truth. The ability to think scientifically does not just happen to every student but needs to be trained in order to develop properly so that students can think logically, systematically, analysis, deductive, and inductive in addressing every problem that occurs as part of scientific thinking.
Indonesia has an environmental-based education program. It is Adiwiyata. Almost all schools, especially the high school level in the Bandung city, have participated in the program and received Adiwiyata awards. The implementation of the Adiwiyata program can run well if the students have scientific thinking skills in dealing with various environmental problems. Scientific thinking skills are very necessary in environmental problems that occur such as global warming, because one's efforts to understand a problem is the most important part of scientific thinking skills, including high-level thinking skills. Habitual activity is the characteristic of someone who is able to solve problems most effectively and efficiently because they involve skills, and signal attitudes and learn from past experience [17]. The process of intellectual behavior patterns starts from the habit of thinking and creates high-level intelligent behavior because the problem is solved by thinking first before acting. Through this environment-based program, it is hoped that schools can be one of the solutions in reducing global warming because students can provide input problem solving through scientific thinking skills.

The Adiwiyata program has four aspects of its implementation. They are aspects of environmentally friendly policies, aspects of environment-based school curricula, aspects of participatory-based activities, and aspects of managing environmentally friendly supporting facilities. One of the standard aspects that must be implemented by Adiwiyata schools is to implement an environment-based curriculum. In the Adiwiyata program, one thing that must be implemented is curriculum development that develops local and global issues as environmental learning materials. So students are expected to be able to understand environmental issues both in their regions and globally. The issue of global warming issues is an international environmental issue considering the impact will be felt throughout the world.

2. Methods
Design research on scientific thinking skills research in solving global warming problems in students researchers used a quantitative method research approach. Quantitative research is research that emphasizes numerical data (numbers) that are processed by statistical methods [18]. The research sample of 196 people spread in 9 schools. Data obtained by observation, questionnaires, literature study, statistical calculations, and documentation. The data is processed using percentage analysis techniques. With the percentage category formula as follows:

Formula Index% = Total Score / Y x 100 [19]

Information: Total Score = Respondent Answer Score
Y = Maximum Score (Number of Respondents x Highest Likert scale)

Table 1. Rating Intervals

| Percentage       | Criteria   |
|------------------|------------|
| 0% – 19.99%      | Very good  |
| 20% – 39.99%     | Good       |
| 40% – 59.99%     | Sufficient |
| 60% – 79.99%     | Not good   |
| 80% – 100%       | Very Poor  |

The percentage will determine the category of scientific thinking in solving global warming at Adiwiyata school, which is categorized from the five indicators. They are from the aspects of logical thinking, analysis, systematic, deductive, and inductive.

3. Results and Discussion
Scientific thinking is an integration of prior knowledge in studying an event. Scientific thinking is the process of applying scientific techniques to study phenomena, gaining new knowledge that is integrated with previous knowledge through structured thinking and fostering a causal relationship to increase the capacity of thinking skills in solving problems [20]. The reviewed scientific thinking study variables are related to (1) logical, (2) analysis, (3) systematic, (4) deductive, and (5) inductive. Based on the results of the calculation of the performance value through the calculation of the percentage of all research samples, both Adiwiyata and Non-Adiwiyata schools.
3.1 Scientific Thinking Skills on Aspects of Logical Thinking

The ability to think logically has a performance value of 65.63 percent, or more than half have been able to think correctly and appropriately in solving global warming problems. The ability to think scientifically in solving problems in daily life is largely determined by the ability to think properly in determining right or wrong. Logical thinking is classified as a reasonable argument, a way of thinking to find answers to problems by trying to gather information, knowledge, data, and facts to identify what is wrong and what is true according to the logic [21]. The tendency of students is enough to be able to show the answer correctly according to the facts in finding the problem of global warming.

Logical thinking skills in defining the problem as part of scientific thinking skills of students in finding global warming problems, including in the category enough. Because more than half are able to answer that is an average of 67.89 percent. The statements of several teachers and the school revealed almost the same; the development of environmental issues especially global warming has not been integrated or linked to learning, the issue of global warming is conveyed to the subjects in which indeed discuss global warming.

Logical thinking skills in identifying problems as part of scientific thinking skills of students in finding global warming problems are included in the sufficient category. Because more than half are able to answer that is an average of 67.89 percent. Identifying is an effort to recognize something based on what has been found. Identification is very necessary because the problem identification stage is the first step in problem-solving learning.

Logical thinking skills formulate various alternative solutions as part of scientific thinking skills of students in solving the problem of global warming, including in the sufficient category. Because more than half are able to answer that is an average of 67.44 percent. Several solutions to the problem of global warming will emerge after the problem is identified. Alternative solutions are carried out in order to expand opportunities to find various solutions that are innovative and effective in solving problems. Students on the logical aspects of determining alternative solutions have been able to because they tend to choose the right solutions precisely from the several solutions available in the problem.

Logical thinking skills in determining the best solution as part of scientific thinking skills of students in solving the problem of global warming are included in the sufficient category. Because more than half are able to answer the average is 67.33%. The stages in determining the best solution are the end of solving the problem. Students on the logical aspects of determining the best solution tend to be able to choose the best solution in problem solving appropriately.

3.2 Scientific Thinking Skills on Aspects of Analytical Thinking

The ability to think analytically has a performance value of 71.36 percent or more than half already understanding the causality of a complex phenomenon that becomes easy to learn that exists in solving global warming problems. The analysis is a part of thinking to find the cause of a problem. Analytical thinking is thinking based on data and facts that will help find solutions based on the causes of problems and solving problems in everyday problems, including environmental problems [22].

Analytical thinking skills in defining the problem as part of scientific thinking skills of students in finding global warming problems are included in the sufficient category. Because more than half are able to answer that is an average of 76.19 percent. The process of defining the problem will affect problem-solving; the better defining the problem will provide convenience in solving the problem. Students on the defining analysis aspects tend to be able to answer questions about the facts of global warming because the facts of global heating can be felt directly so that it can be defined.

Analytical thinking skills in identifying problems as part of scientific thinking skills of students in finding global warming problems are included in the sufficient category. Because more than half are able to answer that is an average of 60.05 percent. The results of identification in the form of conclusions from the characteristics of objects or concepts that have been studied. The more results obtained, the better so that the clearer the object is distinguished from other objects. Students in the analysis aspect
identify tend to be able to answer questions about the facts of global warming. Students are able to distinguish the characteristics of global warming and climate change.

Analytical thinking skills in determining the best solution as part of scientific thinking skills of students in finding global warming problems including in the category of sufficient. Because most are able to answer that is an average of 80.24 percent. Stages after being able to find various alternatives, then one must be able to compare and determine the best and effective solutions [23]. Students are able to understand the causality of problems so as to determine the best solution to the problem of global warming. Students are confronted with a problem in which there is a problem of global warming, so they are required to be able to determine the best solution from several alternatives.

3.3 Scientific Thinking Skills on Aspects of Systematic Thinking

The ability to think systematically has a performance value of 62.18 percent or more than half has been able to rank in order to classify the problems that exist in solving problems of global warming. Systematic thinking is a process of thinking that streaks or has certain stages. Education requires humans to think systematically in finding the truth of a problem or phenomenon in the era of globalization [24,25].

Systematic thinking skills in defining the problem as part of scientific thinking skills of students in finding global warming problems are included in the sufficient category. Because more than half are able to answer that is an average of 67.23 percent. Systematic thinking is a way of thinking that is interconnected and works between elements or events to achieve goals. The process of defining the problem will affect problem-solving. More than half of the students have been able to define global warming sequentially.

Systematic thinking skills in identifying problems as part of scientific thinking skills of students in finding global warming problems are included in the sufficient category. Because more than half are able to answer that is an average of 68.45 percent. The process of identification of objects or events is carried out in the form of structural analysis, searching for characteristics and recording of what happens to the identification object [26]. Students tend to be able to determine the characteristics of global warming sequentially.

Systematic thinking skills in determining alternative solutions to problems as part of scientific thinking skills of students in finding global warming problems are included in the sufficient category. Because more than half are able to answer that is an average of 64.21 percent. The ability to find alternative solutions is an indication of being able to solve problems. This stage is done after being able to define and identify problems. At this stage, more than one solution can be produced to solve the problem. Students tend to be able to choose several alternative solutions from the many solutions presented in the problem as an alternative solution to global warming.

3.4 Scientific Thinking Skills on Aspects of Deductive Thinking

The ability to think deductively has a performance value of 49.24 percent or less than half already able to provide conclusions about an event from the general to the specifics that exist in solving global warming problems. Deductive thinking uses syllogistic thinking patterns. The syllogism is composed of two statements and a conclusion or from specific to the general [27]. Deductive thinking is done by the mechanism of applying general things first, then connecting them to specific sections.

Deductive thinking skills in defining problems as part of scientific thinking skills of students in solving the problem of global warming are included in the sufficient category. Because less than half are able to answer that is an average of 32.86 percent. Define the problem well will provide convenience in problem-solving, conversely, if not careful in defining the problem will affect the complexity of solving the problem [28]. Learners have not been able to draw conclusions precisely from the articles contained in the problem. Difficulties in drawing conclusions from the article affect the final results of solving the problem of global warming.

Deductive thinking skills in formulating alternative solutions as part of scientific thinking skills of students in solving the problem of global warming are included in the good category. Because more than
half are able to answer that is an average of 71.42 percent. Alternative solutions in problem-solving are very important because every problem cannot be solved in only one way. These alternatives are needed to arrive at the right decision choice with minimal risk [29]. Students on deductive aspects in determining alternative solutions tend to be able to draw conclusions in determining several alternative solutions.

Deductive thinking skills in determining the best solution as part of scientific thinking skills of students in solving the problem of global warming are included in the sufficient category. Because less than half are able to answer that is an average of 46.92 percent. After being able to determine alternative solution formulations, students should be able to choose the best solution drawn from the conclusions of questions made complex according to the concept of deductive thinking.

3.5 Scientific Thinking Skills on Aspects of Inductive Thinking
The ability to think inductively has a performance value of 52.10 percent or more than half already able to provide conclusions about an event from the specific to general / comprehensive that exists in solving global warming problems. Inductive thinking is done by a mechanism that is based on specific things to the general. Inductive thinking is a way to draw conclusions through a process of generalization [30,31].

Inductive thinking skills in defining problems as part of scientific thinking skills of students in solving the problem of global warming are included in the sufficient category. Because less than half-time is able to answer that is an average of 54.99 percent. The tendency of answers of most students is able to provide general conclusions from a phenomenon that is made specific to the problem.

Inductive thinking skills in solving the problem of global warming, including the good category. Because more than half are able to answer that is an average of 65.44 percent. The results of identification in the form of conclusions from the characteristics of the object or concept being studied. The more results obtained, the better so that the clearer the object is distinguished from other objects. In the inductive aspect, the tendency of students' answers is able to draw general conclusions from the specific global warming problem.

Inductive thinking skills in determining the best solution to the problem as part of scientific thinking skills of students in solving the problem of global warming, including in the category enough because more than half-able to answer that is an average of 62.51 percent. The tendency of the answers of most students to be able to provide general conclusions then determine the best solution that is most appropriate in solving the problem of global warming.

The ability to solve problems is one of the outcomes of the learning process. One of the higher-order thinking skills is problem-solving ability. This ability must be developed as an output of the learning process in order to equip students the ability to solve everyday problems in the future, both independently and in groups [32]. Environmental cultured school programs that make students trained with environmental care activities, create scientific thinking skills that will help in solving the problem of global warming, can be concluded some of the efforts that have been made by Adiwiyata schools in solving the problem of global warming. The level of knowledge, attitudes, and behavior possessed by students who implement the Adiwiyata program looks much higher when compared to the level of knowledge, attitudes, and behavior of Non-Adiwiyata school students [33].

The Adiwiyata program has four aspects of its implementation. They are aspects of environmentally friendly policies, aspects of environment-based school curricula, aspects of participatory-based activities, and aspects of managing environmentally friendly supporting facilities. These aspects play a role in conditioning the school environment to accustom environmental problem-solving skills, especially global warming, to students and other school members. The Adiwiyata program implemented by schools must refer to the principles of preservation of environmental functions, pollution control and/or environmental damage.

The efforts of Adiwiyata schools in solving the problem of global warming are more in the habit of maintaining school hygiene. This is the action of saving energy, saving water and electricity, then utilizing waste into compost and others. And the action of a little garbage is better by bringing drinking supplies and own food supplies by reducing plastic waste that will damage the environment. Although
in Non-Adiwiyata schools environmental behavior has been implemented, there are some aspects that do not meet the environmental service assessment to become an Adiwiyata school. But there are also schools that do not want to attend Adiwiyata schools because they already have characteristics in other fields other than the environment that is needed from their schools.

Adiwiyata's implementation in schools is more on the invitation to maintain the cleanliness of the school environment so that students implement various policies in the form of rules that require students to implement them. One aspect of the Adiwiyata program is the environment-based curriculum. One of them is by developing environmental issues, both national and global. The implementation of an environment-based curriculum with the development of environmental issues, especially global warming at school is not yet optimal. Obstacles in the development of environmental issues, especially global warming; teacher's concern and knowledge are still limited; there is no commitment of schools, especially school principals in implementing the Adiwiyata program, there is no evaluation and supervision of the implementation of Adiwiyata by related agencies. The implementation of the Adiwiyata program has not been maximized. One of them is because the Adiwiyata program is not a compulsory program so that the evaluation and supervision of related institutions are still not optimal, the absence of supervision makes there is no responsibility or obligation to implement Adiwiyata aspects in schools so that it depends on school commitment.

4. Conclusion
Based on performance indicators of scientific thinking it is known that the scientific thinking skills of students at Adiwiyata Public High Schools in Bandung are good enough. The skills of scientific thinking to solve the problem of global warming are superior in the aspects of thinking logically and analysis because they fit into good criteria, while the skills in the aspects of scientific thinking systematically, deductively and inductively belong to sufficient criteria in problem solving of global warming.

References
[1] IPC 2013 Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Cambridge University Press, Cambridge, United Kingdom and New York.
[2] Radiana A 2017 Mengenal Program KLHK tentang “Kampung Iklim”. Antasena (Bahana Berita Sains dan Teknologi Atmosfer), 2 (2). 12-14.
[3] Undang-Undang No.16 Tahun 2016 tentang Pengesahan Paris Agreement to The United Nations Framework Convention On Climate Change (Persetujuan Paris Atas Konvensi Kerangka Kerja Perserikatan Bangsa-Bangsa Mengenai Perubahan Iklim)Hidup. Jakarta, Presiden Indonesia
[4] Septian Y 2016 Perlakuan Ramah Lingkungan Peserta Didik Sma. SOSIO DIDAKTIKA: Social Science Education Journal e-ISSN: 2442-9430. 3 (2). 193-201.
[5] Muhaimin 2015 Membangun Kecerdasan Ekologis. Bandung. Alfabeta
[6] Millicent A 2014 Climate Change Awareness and Policy Implications Among Primary School Teachers In Kisumu City, Kenya. Environmental Studies of Kenyatta University.
[7] Santoso 2011 Pengembangan Materi Geografi Integrasi Pemanasan Global (Global Warming) Dengan Metode Problembased Learning Pada Kelas Xi Di Sma N 1 Suroh Kabupaten Semarang. Jurnal Penelitian Pendidikan, 1 (1).111-118.
[8] Raharjo S B 2014 Kontribusi Delapan Standar Nasional Pendidikan Terhadap Pencapaian Prestasi Belajar. Jurnal Pendidikan dan Kebudayaan, 20 (4). 2470-482.
[9] Purwanto N A 2006 Kontribusi Pendidikan Bagi Pembangunan Ekonomi Negara. Jurnal Managemen Pendidikan, 2 (2).1-7.
[10] Maryani E 2017 Penguatan Pendidikan Karakter, Kecakapan Abad 21 dan Literasi Dalam Pembelajaran IPS di SMP Bandung: Universitas Pendidikan Indonesia
[11] Hidayat S R Dkk 2017 Pengembangan Instrumen Tes Keterampilan Pemecahan Masalah pada Materi Getaran, Gelombang, dan Bunyi. Jurnal Penelitian & Pengembangan Pendidikan Fisika. 3 (2). 157-166.
[12] Sutarno et.al 2017 Keterampilan Pemecahan Masalah Mahasiswa Dalam Pembelajaran Bandul Fisis Menggunakan Model Problem Solving Virtual Laboratory. Jurnal Pendidikan Fisika dan Teknologi, 3 (2), 164-172.

[13] Yumrohaini 2015 Penguasaan Kompetensi Belajar Pada Materi Teknik Dan Strategi Pemasaran Dengan Pendekatan Scientific Learning. Journal of Economic Education, 4 (1). 27-31.

[14] Yunus M 2014. Mindset Revolution. Cetakan Pertama. Yogyakarta : Jogja Bangkit Publisher. (p.79-80)

[15] Zulfikar and Budiantara N 2014 Manajemen Riset dengan Pendekatan Komputasi Statistika. Cetakan Pertama Yogyakarta : Deepublish (p.10)

[16] Nugroho I A 2016. Pendekatan Ilmiah Dalam Pembelajaran Lintas Kurikulum Di Sekolah Dasar. Yogyakarta : Workshop. (p.3)

[17] Costa L and Kallick B 2000 Discovering and Exploring Habits of Mind. Association for Supervision and Curriculum Development (ASCD), Alexandria: Beauregard St. (p.2)

[18] Handayani S W 2014 Peningkatan Aktivitas Belajar Akuntansi Melalui Model Pembelajaran Tipe Think Pair Share Berbantuan Media Modul. Jurnal Pendidikan Akuntansi Indonesia, 12 (1). 12 – 20. (p.13)

[19] Widodo J et.al 2013 Peningkatan kemampuan menulis puisi melalui penerapan strategi identifikasi berbasis kecerdasan majemuk pada siswa kelas X-A SMA Negeri 1 Gemolong tahun ajaran 2011/2012. Jurnal Pendidikan dan Sasra 1(1). 37-53. (p.43-44)

[20] Yunus M 2014 Mindset Revolution. Cetakan Pertama. Yogyakarta : Jogja Bangkit Publisher. (p.80-81)

[21] Suryadi, 2012. Pembuatan Peputusan : Konsep, Prinsip Dan Proses. Bandung: Bahan Ajar Jurusan Administrasi, Universitas Pendidikan Indonesia. (p.6)

[22] Trianto 2014 Mendesain Model Pembelajaran Inovatif, Progresif dan Konstektual. Jakarta: Prenadamedia Group

[23] Tompodung 2018 Efektivitas Program Adiwiyata Terhadap Perilaku Ramah Lingkungan Warga Sekolah Di Kota Depok. Jurnal Pengelolaan Sumberdaya Alam dan Lingkungan. 8 (2) 170-177(p176).