Applying Authentic Data Analysis in Learning Earth Atmosphere

H Johan1,2,*, A Suhandi3, A Samsudin1 and A R Wulan4

1 Sekolah Pascasarjana, Universitas Pendidikan Indonesia, Jalan. Dr. Setiabudi No. 229, Bandung 40154, Indonesia
2 Progran Studi Pendidikan Fisika, Jurusan Pendidikan MIPA, FKIP, Universitas Bengkulu, Jalan. Wr Supratman, Kandang Limun, Kota Bengkulu, Indonesia
3 Departemen Pendidikan Fisika, Fakultas Pendidikan MIPA, Universitas Pendidikan Indonesia, Jalan. Dr. Setiabudi No. 229, Bandung 40154, Indonesia
4 Departemen Pendidikan Biologi, Fakultas Pendidikan MIPA, Universitas Pendidikan Indonesia, Jalan. Dr. Setiabudi No. 229, Bandung 40154, Indonesia

*hennyjohan@student.upi.edu

Abstract. The aim of this research was to develop earth science learning material especially earth atmosphere supported by science research with authentic data analysis to enhance reasoning through. Various earth and space science phenomenon require reasoning. This research used experimental research with one group pre test-post test design. 23 pre-service physics teacher participated in this research. Essay test was conducted to get data about reasoning ability. Essay test was analyzed quantitatively. Observation sheet was used to capture phenomena during learning process. The results showed that student’s reasoning ability improved from unidentified and no reasoning to evidence based reasoning and inductive/deductive rule-based reasoning. Authentic data was considered using Grid Analysis Display System (GrADS). Visualization from GrADS facilitated students to correlate the concepts and bring out real condition of nature in classroom activity. It also helped student to reason the phenomena related to earth and space science concept. It can be concluded that applying authentic data analysis in learning process can help to enhance students reasoning. This study is expected to help lecture to bring out result of geoscience research in learning process and facilitate student understand concepts.

1. Introduction

One of the important things in science education is learning process that can stimulate students to use the ability of thinking and reasoning in constructing a concept that has a different character. Concept of Earth is an imaginary in the sense that most of it could not be observed directly [1]. The earth science included earth atmosphere concepts have character which cannot be observed directly and related closely to natural phenomena. For example in Figure 1, solar radiation and earth radiation play a role at a temperature in the upper atmosphere. Ozone layer also gives impact to earth temperature. How they give impact to earth temperature could not be observed directly. This concept also related phenomena of rill condition of earth atmosphere. It affected the student’s conception thus an alternatives conceptions besides the scientific conception aroused [2, 3]. Some research had shown
that most of earth and space science concepts were still considered to be difficult and there were many misconceptions happened, such as moon phase concept [2, 4, 5, 6].

![Sun Radiation](image)

**Figure 1.** Atmosphere layer

The reasoning ability could be developed by analogizing the concept with a scientific model for better understanding a concept [7]. In addition, some research suggests that analogizing the reasoning concepts could be developed during the representations exploration process of concepts [8, 9]. Some implementations to improve the reasoning ability in the geological concept had been done. Analogizing, scientific models, and the graphical representation had been used in geological learning to improve student reasoning ability [7, 10, 11]. Although media visualization had been used widely in learning however it still needed encouraged for using. This research provided media visualization from authentic data to support other media visualization that used to help student increase their reasoning ability. It expected can give different way to help student understand and reason the concept clearly.

Several studies which concern in reasoning had been done. Scientific model had been used as visualization to help student reach their scientific conception [6]. Students’ sketches were explored to investigate the student’s alternative conceptions about plate tectonics using visualization from in learning activity [11]. In addition, collaboration science research and learning research just had been trend among education study. Result of science research used to facilitate student thinking process. Werts S and L Hinov presented visualization in the form of three dimension graph from authentic data that was analyzed by MATLAB [12]. Ellwein A L, Hartley L M, Donovan S, & Billick concerned to develop module based data to facilitate students whom never worked with authentic scientific data [13]. This study provides earth and space science learning program using multi modus visualization such animation, picture, and graph to enhance reasoning. Visualization in this study also came from considering authentic data about Indonesian atmosphere using Grid Analysis Display System (GrADS). Novelty in this study is compilation research science from analyzing authentic atmosphere data using GrADS in learning earth and space science. Advantage of GrADS is easier to operate than using MATLAB. Display result from GrADS closely similar to display result from MATLAB.

### 2. Experimental Method

#### 2.1. Research Design

Quasi experimental with one group pre-test and post-test design was implemented in this research. Before treatment, authentic data was examined using Grid Analysis and Display System (GrADS). Data of atmosphere’s temperature and atmosphere’s pressure on 1990 and 2010 were explored using GrADS. Pre-test was conducted before treatment process. Student engaged to construct the concept interactively with help of authentic data. Students were also engaged to find correlation among concept using visualization from GrADS about real condition of Indonesian atmosphere. Questions and feedback were done along learning activity. Classroom interactive by using questions and feedback was presented to support student improve their reasoning skill. Students were given question to explore the value in atmosphere phenomena. Students were engaged to interpret visualization about real condition of Indonesian atmosphere from GrADS. After treatment process, pos-test was conducted. Last step were analysis and conclusion.
2.2. Research Subject
23 pre-service physics teacher were involved to implement the learning model. Research subject never got earth and space science course before. Convenience sampling was conducted in this research.

2.3. Instrument Collecting Data
For collecting data, some instruments were constructed. Three types of instrument collecting data were developed. It includes essay test, open ended question, and observation sheet. An essay test was conducted to collect data reasoning. Open ended question was castoff to collect data about students’ responses. Observation sheet was used to encounter all phenomena during learning process. Before used, these instruments were validated. 4 experts participated for validating the instruments. These instruments were tested to 34 pre-service physics teacher students who had passed earth and space science course in Bengkulu University, Indonesia. The result showed that instruments were valid and reliable. Detail of developing instrument doesn’t be a focus discussion in this article.

2.4. Learning Process
Research based material in learning process came from science research which analyzed authentic data using GrADS (Grid Analysis Display System). This research tried to harness science research which analyzed authentic data using GrADS and learning activity to help students developed their reasoning skill. Students were encouraged to interpret visualization from GrADS analysis, correlated it to earth concept that learned. In learning activity, various media visualization included media visualization from investigation authentic data using GrADS were charity. Interactive discussions are done during learning activity.

2.5. Analysis Data
Students’ responses from open ended were coded to find the pattern of the responses about learning program. Students’ reasoning skill was examined quantitatively, category for reasoning skill followed criteria from Furtak (2010). Category, score, and description of reasoning skill can be seen in Table 1.

| Category                          | Score | Description of Indicators                                                                 |
|----------------------------------|-------|-------------------------------------------------------------------------------------------|
| Inductive/deductive rule-based   | 4     | The rationale consists of a comprehensive data analysis supported by a principle, theory, |
| reasoning                        |       | law, or definition that are relevant to the data and problem being solved. The scientific |
|                                  |       | correctness of the theory, law, etc., used in this reason is not important.               |
| Evidence-based reasoning         | 3     | The rationale has considered an amount of data (including implicit data) and applied a     |
|                                  |       | relevant data analysis, but not enough to solve the problem correctly.                    |
| Data-based reasoning             | 2     | The rationale relies on limited data or the surface feature of the problem.               |
| No reasoning                     | 1     | The rationale, if any, is merely a restatement of the claim (response) or not clearly related |
|                                  |       | to the problem nor clear in meaning.                                                    |
| Unidentified                     | 0     | Student’s answer sheet is blank                                                           |

3. Result and Discussion
Distribution of students in each level of reasoning criteria before and after implementation of learning model is shown in Table 2.
The shifted of students’ reasoning were obtained from difference in scores pre-test and post-test. Most of students’ reasoning levels before implementation were unidentified (state in level 0). It means students’ answer sheet was blank. Just little of them had no reasoning (state in level 1). Their answer was just a restatement of the claim (response) or not clearly related to the problem. According Table 2, before implementation almost students reasoning were unidentified. They leave their answer sheet blank. Data in Table 3 couldn’t show students’ prior reasoning clearly. It indicates that learning model designed gives positive impact on students’ reasoning development. Students’ reasoning improved form no reasoning to inductive/ deductive rule-based reasoning, evidence based reasoning, data-based reasoning. Student response indicates that student knows prominence principle such solar radiation is absorbed by ozone at stratosphere layer. Temperatures of troposphere are predominantly affected by earth radiation. The air density decreases by elevation. Earth radiation of heat is transferred by air convection. Besides that, student can explain about correlation of temperature and elevation, correlation of stratosphere temperature and ozone layer, and correlation among air density (density is closely related to temperature), temperature, and heat radiation that absorbed. Student’s response indicates that is correlation between air temperature and air pressure.

Media visualizations such animation, graph, table, or picture in learning process were aimed to visual how concepts related one each other to display an atmosphere phenomena. Visualization from GrADS supported visualizations in concept focus. Allegedly, visualizations used in this study helped student to develop their thinking skill and to reason concepts in atmosphere phenomena. Media visualization is technological utilization. Santos, Valéria Campos and Agnaldo Arroio argued that technological resources helped student to get a complete understanding in learning process [15]. Analysis data using GrADS is sample of using technology in learning process. The findings indicated that impact of learning process was as expected. Result of this study relevant on dual coding system theory, human cognition included two cognition systems, verbal system and visual system. Visual system included animation, picture, graph, table, formula mathematic. Based on findings, visualization included visualization from analysis authentic data using GrADS in this study supported human visual system to improve their cognition. Visualization from analyzing authentic data of Indonesian atmosphere’s temperature and pressure also help student understand about temperature and pressure of atmosphere.

Based on Table 2, more than half students (60.9% of participant) were at evidence based reasoning level. Allegedly, their thinking skill improved as impact of learning process in learning model that designed in pre implementation step. Visualizations from authentic data analysis were used to help students understood clearly how an atmosphere phenomena was formed. Visualizations used in this learning process also could show correlation among concepts. This situation facilitated student to reason based on correlation among concept. Werts and Hinnov also reported that correlation among concepts could be explained by animation used in learning activities [12]. This study supported thinking skill that stated by Pressiesein, he stated that thinking was cognition process as mental activity to construct knowledge [16]. Cognition process included perception, reason, and intuition. One of the thinking skills were correlation and causality. Interactive process especially in concept focus using visualizations facilitated student to engage their mental process in thinking. So that, this learning model in Table 2 allegedly facilitated students to construct their knowledge. Learning model designed was harnessed be a factor that support to improvement of students’ reasoning. This is seen from N-

### Table 2. Distribution of students’ reasoning before and after implementation

| Level of Reasoning Criteria               | Score | Before implementation | After implementation |
|------------------------------------------|-------|-----------------------|----------------------|
| Inductive/ deductive rule-based reasoning| 4     | 0                     | 21.70%               |
| Evidence based reasoning                 | 3     | 0                     | 60.90%               |
| Data-based reasoning                     | 2     | 0                     | 17.40%               |
| No reasoning                             | 1     | 21.70%                | 0                    |
| Unidentified                             | 0     | 78.30%                | 0                    |

The findings indicated that student knows prominence principle such solar radiation is absorbed by ozone at stratosphere layer. Temperatures of troposphere are predominantly affected by earth radiation. The air density decreases by elevation. Earth radiation of heat is transferred by air convection. Besides that, student can explain about correlation of temperature and elevation, correlation of stratosphere temperature and ozone layer, and correlation among air density (density is closely related to temperature), temperature, and heat radiation that absorbed. Student’s response indicates that is correlation between air temperature and air pressure.

Media visualizations such animation, graph, table, or picture in learning process were aimed to visual how concepts related one each other to display an atmosphere phenomena. Visualization from GrADS supported visualizations in concept focus. Allegedly, visualizations used in this study helped student to develop their thinking skill and to reason concepts in atmosphere phenomena. Media visualization is technological utilization. Santos, Valéria Campos and Agnaldo Arroio argued that technological resources helped student to get a complete understanding in learning process [15]. Analysis data using GrADS is sample of using technology in learning process. The findings indicated that impact of learning process was as expected. Result of this study relevant on dual coding system theory, human cognition included two cognition systems, verbal system and visual system. Visual system included animation, picture, graph, table, formula mathematic. Based on findings, visualization included visualization from analysis authentic data using GrADS in this study supported human visual system to improve their cognition. Visualization from analyzing authentic data of Indonesian atmosphere’s temperature and pressure also help student understand about temperature and pressure of atmosphere.

Based on Table 2, more than half students (60.9% of participant) were at evidence based reasoning level. Allegedly, their thinking skill improved as impact of learning process in learning model that designed in pre implementation step. Visualizations from authentic data analysis were used to help students understood clearly how an atmosphere phenomena was formed. Visualizations used in this learning process also could show correlation among concepts. This situation facilitated student to reason based on correlation among concept. Werts and Hinnov also reported that correlation among concepts could be explained by animation used in learning activities [12]. This study supported thinking skill that stated by Pressiesein, he stated that thinking was cognition process as mental activity to construct knowledge [16]. Cognition process included perception, reason, and intuition. One of the thinking skills were correlation and causality. Interactive process especially in concept focus using visualizations facilitated student to engage their mental process in thinking. So that, this learning model in Table 2 allegedly facilitated students to construct their knowledge. Learning model designed was harnessed be a factor that support to improvement of students’ reasoning. This is seen from N-
gain value that was obtained in category high. Synergy with result from Carolan, Prain & Waldrip that stated learning process focused on thinking skill and reason ability also supported student understand concept well [17]. Johan a,b,c argued that media visualizations were success to help student improved their reasoning on earth and space science [18, 19, 20].

Finding in this study are supported by data from observation during learning process. Base on phenomena encountered during learning activities, shifted of students’ reasoning was also caused by using visualization from investigating authentic data of earth atmosphere. Visualization atmosphere data from GrADS were harnessed to show how temperature and pressure were related each other in real condition of Indonesian atmosphere. Sample of using visualization from authentic data can be seen in Figure 2.

![Figure 2](image)

**Figure 2.** Display for: (a) temperature in September 1990; (b) pressure in September 1990

According Figure 2, real condition of atmosphere in September 1990 showed that temperature and pressure had inverse correlation. Based on color of visualization, in September northern Indonesia was warmer (represented in red color) than southern one but the pressure was lower in northern than southern one. Werts and Hinnov also reported that visualization from MATLAB could show correlation between slope of incidence angle and incoming solar radiation [12]. Allegedly, visualization from authentic data of atmosphere supported student to understand and reason concept. This allegation supported by data from students’ responses. They testified that visualization from GrADS used in learning activities helped them to understand and reason well. Students were also encouraged to interpret different between earth surface temperature at 1990 and 2010, the factor of it, and the cause of it. Visualization between earth surface temperature at 1990 and 2010 can be seen in Figure 3.

![Figure 3](image)

**Figure 3.** Different between earth surface’s temperatures: (a) March 1990; (b) March 2010

Based on findings and phenomena encountered by observation during learning activities, we argue that applying authentic data analysis in learning process gives some benefits, include: helping students to reason and to understand concepts, giving them different experience learning about real condition of Indonesian atmosphere, showing correlation among concepts, and providing enjoyable learning process. Kortz and Kraft argued that supporting science research in learning activities gave benefit such as improved understanding concepts, skill, thinking, and motivation [21]. Combination between science research and learning research had been trend. Relevance results were also shown in study by
[13]. Kastens revealed that authentic scientific data from scientific research in learning activity could provide an engaging different learning experience. Enjoyable learning could bring out their motivation to learn more active [22]. Allegedly, this motivation contributed to improvement students’ reasoning. This result supported Pratama & Corebima who found that self-motivation also had a contribution in learning to improve cognitive [23]. Data from open ended questions supported these findings where student gave evidence that learning activity was more enjoyable by using animations. It also brings out curiosity, interactive, and interesting. Similarly, Pratama & Corebima stated that geoscience learning using visualization could bring out motivation and encourage like geoscience learning [23]. Motivation was important factors in learning process to be success [24].

4. Conclusion
Based on the analysis of findings, it can be concluded that learning model supported by authentic data analysis using GrADS is potentially enhance students’ reasoning. After implementation, students’ reasoning improved from no reasoning to inductive/ deductive rule-based reasoning, evidence based reasoning, and data-based reasoning. No one of student was in level 1 (no reasoning). Visualization from GrADS supported student to understand and reason concept. Visualization in concept focus step and in research based material were supported each other to help student understand and enhance student’s reasoning. Visualization from GrADS clearly shows the real correlation between air temperature and air pressure in Indonesian atmosphere. Visualization from GrADS clearly shows the real correlation between air temperature and air pressure in Indonesian atmosphere.

Acknowledgments
The authors thank to the Ministry of Research and Technology and Higher Education (Research-Higer Education) for the Doctoral Dissertation Grant Funds. The authors also thank to Septi Johan, M.Si who help to analysis authentic data using GrADS.

References
[1] Sunderlin D 2009 Journal of Geoscience Education 57(1) 73-81.
[2] Miller, Brian W and W F Brewer 2010 International Journal of Science Education 32(12) 1549-1560.
[3] Jolley A, Lane E and Kennedy B, Seneclaude, and Tom-Piere Frappe 2012 Journal of Geoscience Education 60(1) 83-91.
[4] Gross N A and Lopes R E 2009 Astronomy Education Review (8).
[5] Libarkin J C, Asghar A, Crockett C and Sadler P 2011 Astronomy Education Review 10(1) 1-25.
[6] Park Su-Kyeong 2013 Eurasia Journal of Mathematics Science & Technology Education 9(3) 285-299.
[7] Sibley D F 2009 Journal of Geoscience Education 57(4) 255-263.
[8] Prain V, Russel Tytler and Suzanne Peterson 2009 International Journal of Science Education 31(6) 787-808.
[9] Smith G A and Bermea S B 2012 Journal of Geoscience Education 60(4) 350-359.
[10] Smosna R and Bruner K R 2007 Journal of Geoscience Education 55(1) 17-21.
[11] Jee B D, Utal D H, Dedre G, Cathy M., Thomas F S, Basil T, Carol JO and Bradley S 2010 Journal of Geoscience Education 58(1) 2-13.
[12] Werts S and L Hinov 2011 Journal of Geoscience Education 59 219–228.
[13] Ellwein A L, Hartley L M, Donovan S and Billick I 2014 Journal of Geoscience Education 62 578–586.
[14] Furtak E M, Hardy I, Beinbrech C, Shavelson R J and Shemwell J T 2010 Educational Assessment 15(3) 175–196.
[15] Santos, Valéria Campos and Agnaldo Arroio 2016 Journal of Turkish Science Education 13(1) 3-18.
[16] Costa A L 1988 Developing Mind: A Resource Book for Teaching Thinking (Alexandria: ACCD).
[17] Carolan J, Prain V & Waldrip B 2008 *Teaching Science* 54(1) 18–23.
[18] Johan H, A Suhandi and A R Wulan 2016 *Proceeding National Seminar of Elementary Education Mathematic and Natural Science Bandung Indonesia* 123-131.
[19] Johan H, A Suhandi and A R Wulan 2016 *Proceeding National Seminar of SNIPS Bandung Indonesia* 385-389.
[20] Johan H, A Suhandi and A R Wulan 2017 *Proceedings International Seminar on Mathematics, Science, and Computer Science Education* 175-181.
[21] Kortz K M and KJ van der Hoeven Kraft 2016 *Journal of Geoscience Education* 64(1) 24-36.
[22] Kastens Kim 2010 *Journal of Geoscience Education* 58(2) 52-57.
[23] Pratama A T and A D Corebima 2016 *International Journal of Environmental & Science Education* 11(18) 11007-11017.
[24] Mc Connell D and Khatrien, J V H K 2011 *Journal of Geoscience Education* 59(3) 106-110.