Enhancing Students' Mastery of Earth Science Concept through Interactive Conceptual Instruction Supported by Visualization and GrADS

by Henny Johan

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ABSTRACT

Most of earth and space science concepts are unobservable and require reasoning. Character concepts that unobservable directly make students fell difficult to understand the concept correctly. It needs visualization to help understand the concepts easily. The aim of this study was to enhance students' mastery concept in learning earth science, especially earth atmosphere, using interactive conceptual with visualizations and harnessing authentic data analysis using GrADS (Grid Analysis Display System). 23 pre-service physics teacher students in Bengkulu, Indonesia participated in this study. This study used quasi experimental, one group pretest-posttest design. The data were collected using pretest and posttest, questionnaire, observation. Pretest and posttest were analyzed quantitatively, while questionnaire was analyzed qualitatively. The results showed that student's mastery concept improved from no mastery to competent with average normalized gain being 0.64 (criteria moderate). This study tried to take advantage from earth science research which analyzed authentic data using GrADS to help students understand the concept easier and also clearly. This compilation gave them experience about real condition of solar radiation in Indonesian atmosphere in their learning activity. It can be concluded that earth science learning using interactive conceptual supported visualization and GrADS can enhance students' mastery concepts.

KEY WORDS: *earth science, interactive conceptual, mastery concept, visualization, GrADS.*

INTRODUCTION

The analysis result of Geo-Sciences concept showed that most of earth atmosphere concepts require reasoning. Most of phenomenon in earth atmosphere can't be observed directly. Various media visualization can be used to explain the concept of earth atmosphere. Geo-science concept is imaginary and most of the concept can't be observed directly (e.g. Sunderlin, 2009; Park, 2013), including concepts in earth atmosphere learning. It also supported by Rosnita (2016) that stated 78% of respondent agree that earth and space science concept were quite complicated and abstract. The character of phenomenon that unobservable directly makes student fell difficult to understand the concept correctly. It requires learning that constructed precisely to improve student's mastery concept. That appears different alternative conceptions beside scientific conceptions (e.g. Miller & Brewer, 2010; Joley, Lane, Kennedy, & Seneclauze, 2012). Result of a study that used learning model Search, Solve, Create and Share (SSCS) problem solving in Bengkulu City showed that improvement of mastery concept after implementation only in category medium with N-gain being 0.49 (Johan, 2014). These studies indicate that mastery concept of college student in Bengkulu still must be focus in learning activity. Integrative learning model especially Interactive Conceptual Instruction (ICI) has been advanced widely. The purpose of this approach was to comprehend the concepts (e.g Samsudin, Suhandi, Rusdiana, and Kaniawati, 2016). The ICI established in this research is more accents on evocative learning to enhance students' mastery about earth and space science learning. This research offer The ICI in supported by authentic data of atmosphere phenomena as research based material.

Mastery concept can be developed by analogize the concept using a scientific model for understanding a concept (e.g. Sibley, 2009; Park 2013). In another way, some researches show that mastery concept can be improved by representation of concepts, such as sketch visualization and animation (e.g. Prain, Tytler, & Peterson, 2009; Smith & Bermea, 2012). Analogy, scientific models, and graph are used in some geoscience research to improve college

student's mastery concept (e.g. Smosna & Bruner, 2007; Sibley, 2009; Jee et al., 2010). Phenomenon that happen in nature can be understood, observed, and interpreted by help technology. Animation is a sample of using technology in learning activity. Learning activity using of technological resources helps student to get a complete understanding. Deep understanding of the relationship between confidence in science, and technology and environmental attitudes are needed by students thought out various study (e.g. Bezen, Aykutlu, & Bayrak, 2016; Santos, 2016; Koc & Kuvac, 2016). Visualization in geoscience learning can support students to improve their mastery concept. This research provided visualization from multi modus visualization, including animation, figure, and graph. It supported each other to help students understand concept easier. Visualization using in this research also came from analyzing authentic data using GrADS. Students were engaged to interpreted visualization from GrADS.

Mastery concept is an important aspect in learning. Media visualization had had been not used widely in Bengkulu, especially in earth and space science learning. Students' sketches in learning activity were used to investigate the alternative conceptions about plate tectonics (Smith and Bermea, 2012). Sibley (2009) harnessed scientific model to analogize concept for understanding concept. In addition, harnessing science research in learning just had been trend among education study. Result of science research used to facilitate student thinking process, gave different learning experience. Werts and Hinnov (2011) harnessed Matlab to considered authentic data and present visualization in the form of three dimension graph. Ellwein, Hartley, Donovan, & Billick (2014) developed module based authentic data to give experience of authentic scientific data analysis. This research harnessed Grid Analysis Display System (GrADS) to analyze authentic data of Indonesian atmosphere. Engaging students to interpreted visualization of authentic data from GrADS gave students experience about earth science learning through classroom activity. It supported student to understand concept and provided different learning process. Harnessing Grid Analysis Display System (GrADS) in learning process especially earth and space science learning program is not yet reported. Result from GrADS and Matlab is closely similar. GrADS is more guileless to operate than Matlab.

AIM

The aim of this study is to enhance student's mastery concept in learning earth science, especially earth atmosphere, using interactive conceptual with help visualizations and Grid Analysis Display System (GrADS).

METHOD

Research design

This study used quasi experimental research design. One group pretest-posttest design had been utilized. Steps in this research include three steps: pre intervention, intervention used One group pre-test post-test design, and post intervention. In pre intervention step, types of visualization media for each concept in earth atmosphere were identified qualitatively to improve the mastery concept. Designing learning program and instruments collecting data were also developed. In this step, earth atmosphere learning using interactive conceptual was developed. Interactive conceptual learning includes four parts. They are concept focus, using text, interactive classroom, and research based material. Research based material came from science research which analyzed authentic data using GrADS (Grid Analysis Display System). Authentic data of net solar surface radiation in 2010 from January to December were investigated using

GrADS to get visualization about real condition of Indonesian's atmosphere. These visualizations were castoff to support learning activities. This study strained to take advantage from science research which examined authentic data using GrADS to help students understand the concept easier and also obviously. In intervention step, earth atmosphere learning using interactive conceptual with visualization was applied. 23 pre-service physics teacher students in Bengkulu, Indonesia contributed in this study. The participants never contracted earth and space science course before. Convenience sampling was used in this study. Last step is post intervention. In this step, shifted of students' mastery concept were considered from pretest and posttest score. Data of mastery concept was examined by difference between pretest and posttest score and then N-gain was calculated (Meltzer, 2002).

$$g = \frac{S_{post} - S_{pre}}{S_{max} - S_{pre}} \quad ; \qquad S_{post} = \text{posttest score}; \; S_{pre} = \text{pretest score}; \; S_{max} = \text{maximum score}$$

Instrument Collecting Data

For collecting data, some instruments were created. Multiple choice questions were castoff to collect quantitative data of mastery concept while open ended questions used to collect data about student's responses. Sample of question in multiple choice questions can be seen below. Figure 1 was used to represented annual solar movement.

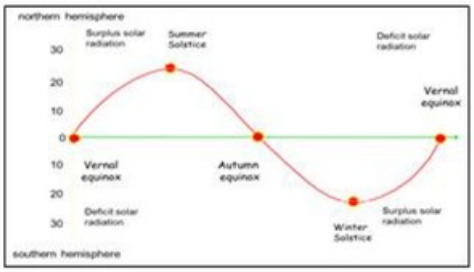
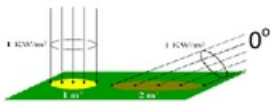
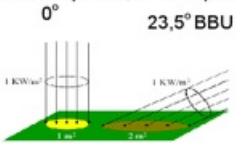


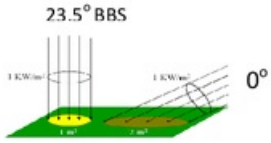
Figure 1. Graph of annual solar movement

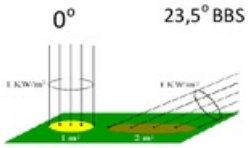
Look carefully at the graph. Based on the graph above, incoming solar radiation on 23,5° of northern hemisphere at summer solstice is represented by figure....

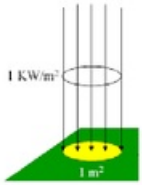
(Note: BBS is southern hemisphere; BBU is northern hemisphere; 0° is equator)

a. 

b. 

c. 

d. 

e. 

İncoming solar radiation at 23,5° BBS= 23,5° BBS= 0°=1KW.m^2

The instruments in this study were validated by expert team. 4 experts participated for validating the instruments. These instruments were verified to 34 pre-service physics teacher students in Bengkulu, Indonesia who had conceded earth and space science course. The result presented that instruments were valid and reliable. In this article, detail result of developing instrument doesn't be an emphasis of discussion.

Learning Activity

Learning program developed in this study is modified from interactive conceptual instruction. Common design of learning model that established in this study can be seen in Table 1. Below:

Table 1. Common design of learning model in this study

Concept Focus: Visualizations are used to help student understand concept	**Class room interaction:** Discussions are done during concept focus, use of text, and using research based material.
Use of Text : Literature book and handout are used to find the key word about concept that visualized	
Research Based Material: harnessed science research which analyzed authentic data using GrADS (Grid Analysis Display System) to help students understand the concept easier and also clearly	

In pre experiment step of this study, visualization type was recognized qualitatively for each concept in earth atmosphere material. This learning included 5 concept of earth atmosphere: composition of air mass, atmospheric pressure, atmospheric temperature, ozon layer, and incoming solar radiation. Visualization used in this study included animation, graph, figure, and visualization from GrADS. Suitable visualization expected can facilitate the students increase their thinking skill and understand concept easier and clearly. These visualizations are applied in learning program that has been developed.

RESULT AND DISCUSSION

Implementation the learning program used pre-test and post-test. Pretest was given before learning activity to know student's prior knowledge and post-test was given after learning activity to know the impact of learning activity. The shifted of students' conceptual in each concept are shown in Table 2 below:

Table 2. Shifted of mastery concept in each concept

Understandings	Compositions of air mass	Atmospheric pressure	Atmospheric temperature	Atmospheric temperature	Ozone layer	İncoming solar radiation
Taxonomy level	C2 understanding	C3 applying	C2 understanding	C3 applying	C4 analysis	C4 analysis
Correct answers in Pre test	13%	30.5%	52.1%	39.1%	30.5%	47.8%
Correct answers in Post test	30.5 %	95.7%	100%	91.3%	47.8%	95.7%
Difference between pre and post	17.5%	65.2%	47.9%	55.2%	17.3%	47.9%
N-Gain (Improvement)	0.2	0.93	1	0.86	0.25	0.92
Category	low	high	high	high	low	high

Taxonomy level in this study used taxonomy bloom revision (Anderson and Krathwohl, 2001). Based on table 3, impact of atmosphere learning indicates an improvement for the mastery concept although two concepts are still low enhancement while other concepts are high enhancement. The low one is just understanding of taxonomy level. Both cases in analysis level show contradictive improving result where one of them is high and another one is low. This is interest to discuss. İmprovement of student's mastery concept can be indicated from pre-test and post test score. Table 2 appearances that total correct answer in post-test and pre-test are different. The highest total of correct answers for pre-test is just 52.1% in concept of atmospheric temperature and the highest total of correct answers for post-test is 100% in concept atmospheric temperature. The distributions of college student in each group of N-gain category show that most of student's mastery concept improvement mostly in category medium. No one stay in category low. Distribution of N-

gain in each category indicates that learning activities give a good impact for improving students' mastery concept. Average of N-gain value of mastery concept in this study is 0.64 in category moderate.

After implementation learning program, student's mastery concept is shifted from under competent to conceptual level. N-gain distribution for mastery concept can be seen in the following Table 3:

Table 3. N-gain distribution for mastery concept

N-Gain	Category	Student
$g > 0,7$	High	7 person
$0,3 \leq g \leq 0,7$	Medium	16 person
$g < 0,3$	Low	none

Result from authentic data using GrADS (Grid Analysis Display System) is also an importance finding in this study. In this study, science research is prospective to support learning research. Sample of visualizations about real conditions of surface net solar radiation on Indonesian atmosphere during 2010 are shown in Figure 3. Visualizations from result analysis of surface net solar radiation from GrADS in Figure 3 show incoming solar radiation on Indonesian's atmosphere. That is influenced by latitude and position during annual solar movement. Incoming solar radiation influences temperature and pressure in atmosphere. Red color means surplus solar radiation than blue one. The result of this science research can support learning atmosphere in concept atmospheric pressure, concept atmospheric temperature, and concept incoming solar radiation (insolasi). It can help to explain correlation among some concepts. For example, it can help to explain about correlation between incoming solar radiation and temperature of atmosphere. It seems learning activity supported by science research facilitate student to understand concept easier. Surface net solar radiation in Indonesians' atmosphere in March, June, September, and December 2010 can be seen in Figure 2 below:

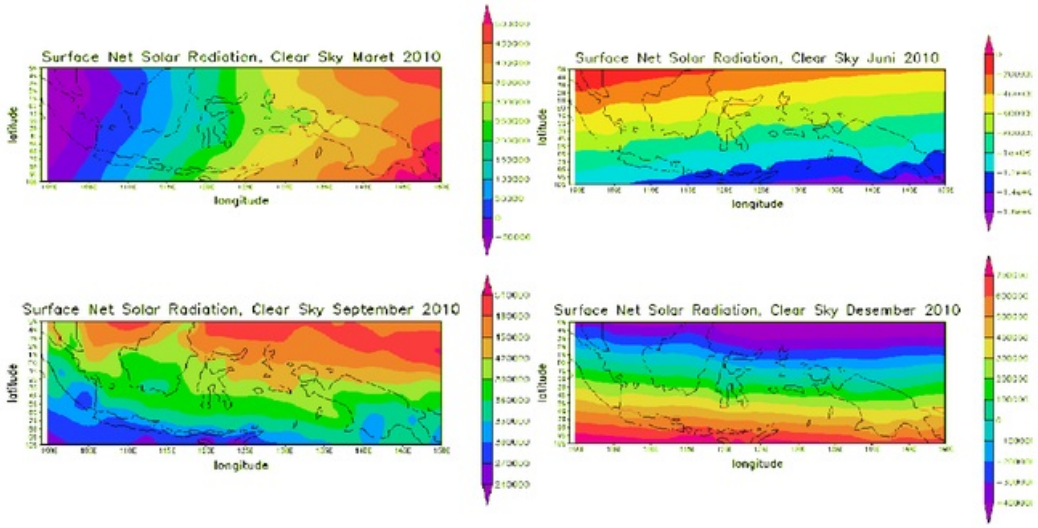


Figure 2.Surface net solar radiation in Indonesians' atmosphere in March, June, September, and December 2010.

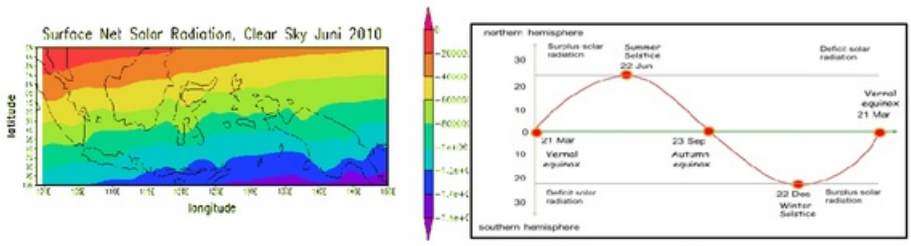
Based on the finding, shifted of mastery concept of each concept is shown in Table 2. Mastery concept for concept atmospheric pressure, atmospheric temperature, and incoming solar radiation improve highly. But enhancement of mastery concept for concept composition of air mass (understand level in Bloom Taxonomy) and ozone layer (analysis level in Bloom taxonomy) is low. İt seems type of visualization used was influence the mastery concept. Visualization for concept of air mass composition was table and graph. Student responses in questionnaire showed that animations help

them more to understand concept easier. This support Benzen's (2016) result, it indicates that animation should be effectively support learning process. Base on Table 2, other interest thing is both cases in analysis level (C4) show contradictive improving result. Enhancement of mastery concept for ozone layer concept is low but enhancement of mastery concept for incoming solar radiation concept is high. In learning activity, compilation animation and visualization from GrADS were used to explain incoming solar radiation concept. Supposedly, this compilation influenced students' mastery for concepts in analysis level. This compilation helped student understand concept easier and clearly. This allegation was supported by qualitative data from students' responses. They testify that visualization of real condition in Indonesian atmosphere (from GrADS) helped them understand atmosphere concepts deeply.

Table 3 shows that most students are in category moderate and high of their N-gain for mastery concept. N-gain average of student's conceptual is 0.64 in category moderate. The improvement of student's mastery concept may be caused by visualization in learning activity. Media visualizations used in learning activity are able to visualize the partial of a natural phenomenon in Earth and Space science concept. This helps students to understand the concepts. Media visualization especially animation can show clearly how these concepts relate to each other in a natural phenomenon within the scope earth and space science especially earth atmosphere. Media visualization is a supporting media that facilitate students to improve their mastery concept. Animation that explains the phenomenon can help students to understand some of the concepts simultaneously at the same time. Various concepts are needed to explain a natural phenomenon. These results are consistent with student's response in questionnaire. They state that animations help them to understand concept. Animation can visualize unobservable directly concept in earth and space science. Presseisen at Costa (1988) reveals one of the thinking skills is correlation including partial thinking skill and totality, pattern, analysis and synthesis, sequences and logical deduction. Student's response in this study also shows similar opinion. Based on the students' responses to the questionnaire, there was evidence that students had obtained considerable benefits from learning. Students' responses supported the finding in quantitative data. Qualitative data from students' responses to the questionnaire showed that all students testified:

1. Earth science learning using visualizations was more interesting
2. Earth science learning using visualizations facilitated them to understand concept of earth atmosphere easier, especially using animations
3. Visualizations in learning activity help them to think about cause, effect and relationships between concepts.
4. The animation was very clear, help to simplify concepts.
5. Animations make learning activity was more enjoyable. It also brought out curiosity, interactive, and interesting.

Based on the phenomena encountered by observation throughout learning earth atmosphere, we argue that applying science research in learning research help students understand the concept easier and give them different experience learning about real condition of solar radiation in Indonesian atmosphere. Relevance results are also shown in study by Ellwein, Hartley, Donovan, & Billick (2014). It reveals that authentic scientific data from scientific research in learning activity can provide an engaging learning experience. Using visualization from GrADS to support learning proses can be explained with Figure 3 below:



(a) (b)

Figure 3.(a).Surface net solar radiation in Indonesian atmosphere, June 2010; (b). Annual solar movement

Based on Figure 4 above, students are asked to relate net solar radiation and sun's motion during a year. Based on Figure 4b, student can see clearly that sun is on northern hemisphere and this why northern Indonesian has surplus solar radiation on June. Based on student's responses, they recognize that this activity also facilitate their high order thinking and help them understand the concept more clearly. Synergy with Lowe (2004), animation that used in learning gives dynamic situational of an object and this is potential to explore logic thinking. Form both Figure 4a and 4b, concepts incoming solar radiation and temperature of atmosphere can be explained. Correlation between concepts also can be explained by this visualization. This is similar with Werts & Hinnov (2011) that stated visualization could explain the correlation among various variable. Improvement of mastery concept is also influenced by learning process that stimulated student's curiosity and motivation. Similarly, Pratama & Corebima (2016) found that self-motivation also had a contribution to cognitive aspect. Kali (2003) showed similar result, virtual visualization as a game in learning activity could improve enthusiasm or interest in learning. Kastens (2010) stated that geoscience learning activity using visualization could give motivation and encouraged like geoscience learning. Supported by Khoiriah (2016) that stated multimedia teaching materials including text, graphics, images, audio, video and animation gave more significant effect on students' cognitive. Mc Connell, David & Khatrien (2011) revealed that motivation was important factors for learning activity to be success.

CONCLUSION

Based on the result and discussion above, it can be concluded that learning earth atmosphere through conceptual interactive using visualizations potential to improve student's mastery concept. Student's mastery concept improve from no understanding to understand concept level with the average normalized gain being 0.64 (moderate) with the help of visualization. Visualization from authentic scientific data about solar radiation analyzed using GrADS help students understand the concept easier, give them experience about real condition of solar radiation in Indonesian atmosphere. The improvement student's conceptual levels indicate that visualization makes learning more interesting and explore student's thinking skill. Visualizations give details of the concept (phenomenon) clearly. It rings out the curiosity and questions from the students to understand concept deeply. Visualization used is also show the relationship of various variables or concepts in an earth atmosphere phenomenon. Next research, applying science research in learning process can be more exploited.

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