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# Development Climate Changes Lecturer in Earth Science and Space Course and Environmental Course for Pre-Service Science Teachers

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**Abstract:** Earth Science and Space Course is a compulsory course for students of Physics Education meanwhile environment and human is a compulsory course for student of Biology Education. Collaborating climate change into those course, needs special approach. The research used developmental research which divided into two phase, exploration phase and cycle process phase. Exploration phase aim to exploration theory for develop the content of climate changes and cycle process aim to knowing student respond after got the lecturer. This research involve 54 students from Physics Education and 56 students from Biology Education from two state universities. Based on the findings, climate changes can be used as the context of those courses on seven topics. They are 1) climate system; 2) solar radiation as the main and local climate controls; 3) atmosphere and its interaction with the hydrosphere and terrestrial; 4) the character of the hydrosphere (ocean) and its interaction with the earth land; 5) changes in earth's surface cover and its effects on the climate system; 6) the theory of climate changes; 7) human roles on climate changes. Students give positive responds to the course and argue that system based content development makes students' understanding of climate changes better.

## 1 INTRODUCTION

The contents of climate change is a compulsory part of science subject. It leads students to earn sufficient knowledge and skills on creating a new pattern of human behavior towards climate change because it is written on curriculum explicitly (Tbilical Treaty, 1977). In the Indonesian Science Education Curriculum, the context of climate change enters and progresses significantly on KTSP curriculum (BNSP, 2006) and on the 2010 curriculum. In the 2013 curriculum, the climate change context is on the basic competence (Kompetensi Dasar - KD) 3.10, basic competence 4.13, and core competence (Kompetensi Inti - KI) 4 in the seventh grade. There is strong relationship between students' learning outcomes and the teachers' preparation of teaching (Darling-Hammond, Bransford, LePage, Hammerness, and Duffy 2007; Marzano, Pickering and Pollock 2001; Fortner, Corney and Mayer 2005). Therefore we have to ensure that teachers are willing and able to provide qualified education on the topic of climate change effectively. Some studies report that attitudes,

mastery of knowledge content, and pedagogical understanding of teachers influence the success of teacher learning in the classroom (Rule 2005; Summers, Kruger, and Childs 2000; Summers, Kruger, Childs, and Mant 2001; Ko and Lee 2003; Kim and Fortner 2006).

Environmental education for pre-service teachers is not officially and systematically arranged in the national curriculum so that implementation is varies in many department and study program (McKeown 2000; Powers, 2004; Mastrilli, 2005). The research discusses the development of a system-based climate change context (i.e. the earth system) and its impact on pre-service Biology and Physics teachers' contents understanding.

## 2 RESEARCH METHODS

The development of climate change content lecturer uses development research frame as shown in Figure 1.

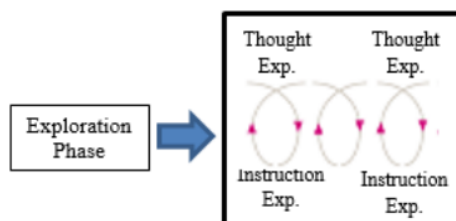


Figure 1: Development research framework.

### 3 RESULTS AND DISCUSSION

Based on the development research phase in methodology, the results in accordance with the phase.

#### 3.1 Exploration Phase

Condition of the context of climate change at universities is usually incorporated into topics of environmental education, environmental science education, and ecosystem education (Mkpa, 2013; Osaat, 2013; Compassion in World Farmageddon, 2014). Environmental education focuses on the functions of the natural environment, human as environmental management, and the development of settlements and urbanization dominantly. Ecosystem education is about the aspects of biodiversity, conservation biology and all aspects of the ecosystem. Whereas, environmental science education covers physics, biology, chemistry, and solutions related to environmental problems. Based on the analysis, the courses developed are embeded in the existing lectures so that only seven meetings on Environmental Education Lectures and seven meetings on the Earth and Space Science Lecture.

The minimum standards that was developed in the curriculum was concern on the minimum NOAA standards. It sets the interconnection 2 climate systems into seven important principles: 1) The Sun is the primary source of earth energy in the Earth's climate system; 2) Climate is affected by complex interactions among components of the earth system; 3) Life in the earth depends and shape by climate; 4) Climate variation depends on space and time either through natural process or human intervention; 5) The understanding of the climate system is enhanced through observation, theoretical studies, and modeling; 6) Besides natural factors, human activities affect the climate system; 7) Climate change affects to earth system and human life

(NOAA, 2009). It affects to five components of climate system components. They are atmosphere, hydrosphere, biosphere, geosphere, and cryosphere. According to this minimum standard, we used pruned instrument (Pruneau *et al.*, 2001) to figure out existing learners' knowledge about climate system.

Learning Outcome of the research was focused on the mastery of content and system thinking ability. Climate change is a multicultural content because it involves different disciplines such as physics, biology, chemistry and earth sciences. Mastering the climate change content needs understanding its content and the interaction among consisting its contents. Therefore, to formulate the learning outcome of context mastery, is used paradigm concept inventory which is divided on basic content and advance content. Basic content consists one or two content learning outcome. Whereas advanced content consists of three or more content learning outcome.

Based on exploration phase, the developing of climate change content with system-based approach, starts from the earth system and is limited to species or individual systems. The science system associated with the climate system can be seen in Figure 2.



Figure 2: Science system on climate system.

#### 3.2 Blue print of Developed Syllabus and Curriculum

The form of developed syllabus and curriculum using the application of natural sciences learning in curriculum system which is a) Mapping concept or content in the system or component of system (subsystem); b) Choosing several hierarchies of system and subsystem which may be developed in one series of learning; c) Initiating learning from pictures / contextual cases to represent system discussed in learning; d) Aim learning using system thinking indicator e) Whenever software is available (highly recommended to use software as aid),

teachers are able to assign students to make model based on their own perception on system they have learned

### 3.3 Students Responses

Through questionnaire with 1-5 scale, students' perceptions about the implementation of syllabus (learning strategies and sub-topics in each meeting) were assessed in order to assess their content understanding of the climate change content. Data can be seen in Table 1.

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Table 1: Students' perception on the implementation of content curriculum in climate change.

No	Content	Physics Education Program	Biology Education Program
1	Climate and climate system	3.9	3.9
2	Role of the sun in climate system	4	4.1
3	Changes in atmospheric composition	3.8	3.9
4	Terrestrial (biosphere) and interaction with oceans	3.9	3.7
5	Earth's surface changes	3.9	3.8
6	Carbon print	4	3.9
7	Theory of climate change	4.1	4.09

Based on the data in Table 1, students argue that the role of the sun in climate system topic is influence student better than others to understand about climate system. Climate system evolved under the influence of internal dynamics and changes of external factors (forcing). External forcing include natural phenomena such as volcanic eruptions, solar variations, human influences which is changes the atmospheric composition.

Sun is dominant factor in the climate system of the earth. There are three fundamental ways to change the balance of the earth's radiatio: 1) Changing the radiation of the incoming sun radiation (e.g. by changes in the earth's orbit or the sun itself); 2) Changing the fraction of reflected solar radiation (called 'albedo'; for example, by changes in cloud cover, atmospheric particles or vegetation); and 3) Change the long-wave radiation from earth back into space (for example, by changing the concentration of

greenhouse gases) (Beer *et al.*, 2000; Hoyt and Schatten, 1997).

Student also argue that Subjects of Environmental Education (in Biology study program) and Earth Science and Space (in Physics education program) have a good role to support the course of climate change. Environmental education in human and environmental course are contain prerequisites knowledge mainly when discusses about the function of the natural environment, human as environmental management, and the development of settlements and urbanization. While the course of Earth Science and Space mostly dealt with the earth system and space as a whole.

The curriculum development of a system-based climate change is based on several pre-existing climate frameworks from NOAA (2009) that regulates the interconnectio of climate systems into seven important principles: 1) The Sun is the primary source of earth energy in the Earth's climate system; 2) Climate is affected by complex interactions among components of the earth system; 3) Life in The Earth Dependeds and shaped by climate system; 4) Climate variation depends on space and time either through natural process or human intervention; 5) The understanding of the climate system is enhanced through observation, theoretical studies, and modeling; 6) Besides natural factors, human activities affect the climate system; 7) Climate change affects to earth system and human life (NOAA, 2009). The NOAA document recognizes that to understand these interconnected concepts requires a system-minded approach, which means the ability to understand complex interconnections among all components of the climate system. Shepardson *et al.* (2012) developed a curriculum based on environmental changes. Each components of the climate system such as the sun, atmosphere, geosphere, hydrosphere, biosphere, cryosphere and humanosphere is similar to the Earth Science and Space Course (Shepardson *et al.*, 2012).

## 4 CONCLUSIONS

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Based on the research findings and discussion, it can be concluded that:

- The development of curriculum content in a system-based climate change context can be divided into seven topics: climate and climate systems, the sun as a dominant component of the climate system, changes in atmospheric composition, terrestrial and oceanic relations,

surface cover changes, carbon footprint, and climate change theory.

- The developed learning strategies can help pre-service Biology and Physics teachers in mastering the content and context of climate change, especially on the case discussion methods and hands on - minds on activities during the lectures.
- The most helpful topics for pre-service Biology and Physics teachers is the development of system-based curriculum content on the topic of climate change theory and the dominant role of the sun in climate change. They understand the content and context of climate change both in human and environmental course and also earth and science course.

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## APPENDIX

### PROGRAM PLAN AND SEMESTER LEARNING ACTIVITIES PROGRAM STUDY OF BIOLOGY EDUCATION FACULTY OF TEACHER TRAINING AND EDUCATION OPEN UNIVERSITY

1. Course: Climate change/ Embedded within \_\_\_\_\_
2. Code/Credit Hour: 1 / 2
3. Prerequisite: General Biology
4. Status: Obligatory
5. Lecturer:

1. **11**ort Description: this course studies about global warming and climate c**13**ge by using climate system as basic science. Global warming and climate change occur due to changes in climate components both naturally and anthropogenically dominated by human consumptive behavior. The topics studied in this course include introductory climate systems to introduce the student to behavioral systems **14**enerally and climate systems in particular, global and local climate control, atmosphere characteristics and their interaction with the hydrosphere and geosphere, th**14** hydrosphere (oceans) characteristics and their interaction with the land, changes in the **26**th's surface cover and its effects on climate systems, climate change theories, and the role of humans to climate change resulting in anthropogenic climate change.

## 2. Learning Outcome

Upon completing the course, students are expected to:

- have a basic knowledge of s**3**nce related to the climate system, especially the topic of global warming and climate change in human and environmental subjects
- have the ability to think scientifically, e**3**pecially thinking systematically, particularly in the topic of global warming and climate change
- have the ability to apply knowledge of climate system to solve environmental problems
- have the ability to cod**5**rate and communicate related to the issues of global warming and climate change and its impacts for people and the environment

## 3. Competencies

- Students are able to recognize the characteristics of climate system components and interactions between components
- Students have the ability to recognize the **7**aracter, structure and function of the components of the climate (Atmosphere,

Geosphere, Hydrosph**7**, Cryosphere and Biosphere) in the frame of the climate system

- Students a**11**ble to understand that changes that occur in a component of the climate system will result in changes in other components and subcomponents of the climate system
- Students are able to understand that the peak condition **13**ne change in climate components will cause global **3**arming and climate change
- Students are able to predict the impact of global warming and climate change on climate and human components.
- Students are able to recognize that consumptive **19**avior in energy and food will affect the components of the climate system and impact climate change and global warming.
- Students are able to identify and analyze the **12**tionship between the structure and function of the components of the climate system
- Students have the ability to understand the **7**atterns of interaction that occur between the components of the climate system
- Students are able to **12**e modeling of the interaction patterns on the components of the climate system
- Students have the ability to predict and retrofit changes in patterns of interaction on climate systems culminating in climate change and global warming
- Students **25**ve systemic thinking skills especially on the topic of climate change and global warming

Meeting	24 Core Concept	Duration	Teaching Strategy
1	<p><b>CLIMATE SYSTEM</b></p> <p>The climate system is the sum of the processes and interactions between the Earth's atmospheric components, the hydrosphere (ocean), cryosphere, the geosphere, and the biosphere that are influenced by solar radiation absorbed by the earth's surface. Climate is different from the weather. The weather is the latest atmospheric conditions including temperatures, rainfall, wind and humidity while climate is the general weather conditions. By comparing daily temperatures with average climate data, students will understand that the weather has a higher variation in comparison with climate</p>	2x 50 minutes	<p><i>Yoyo System Based Case</i></p> <p><b>Method</b> Discussion Case analysis</p>
2	<p><b>THE CONTROL OF THE MAIN AND LOCAL CLIMATE</b></p> <p>The main and local climate controls are solar radiation that interacts with the climatic components of the ocean (hydrosphere), land (geosphere), ice and snow (cryosphere), atmosphere and biosphere. The interaction of solar radiation with climate components will produce a sensible heat that culminates in latent heat. The climate system is determined by temperature and precipitation and is controlled by the balance between radiant energy coming from the sun and the energy returning to space.</p>	2 x50 minutes	<p><i>Yoyo System Based Case</i></p> <p><b>Method</b> Discussion Analisis kasus</p>
15 3	<p><b>THE CHARACTER OF ATMOSPHERE AND ITS INTERACTIONS WITH HYDROSPHERE and THE LAND (BIOSPHERE and GEOSFER)</b></p> <p>The atmosphere layer is a mixture of invisible and colorless gas. It consists of layers of troposphere, stratosphere, mesofer and thermosphere interacting with oceans (ocean) and land (biosphere and geosphere) in influencing climate systems in the form of water vapor and biogeochemical cycles</p>	2x 50 minutes	<p><i>Yoyo System Based Case</i></p> <p><b>Method</b> Discussion Case analysis</p>
1 4	<p><b>THE CHARACTER OF HYDROSPHERE (SEA) AND ITS INTERACTIONS WITH THE LAND</b></p> <p>Hydrospheres or oceans take large portions of absorption of solar and CO<sub>2</sub> radiation. Its interactions with other components of the climate system such as land (geosphere and biosphere) and ocean ecology will affect the climate system in general.</p>	2x 50 minutes	<p><i>Yoyo System Based Case</i></p> <p><b>Method</b> Discussion Case analysis</p>
Meeting	Core Concept	Duration	Teaching Strategies
5	<p><b>THE CHANGE OF EARTH SURFACE CLOSURE AND ITS EFFECT ON CLIMATE SYSTEM</b></p> <p>Changes in Earth's surface cover on the Cryosphere, Geosphere and Biosphere components) have an impact on sunlight, carbon sink, biogeochemical cycles and will eventually affect the climate system and its components and the ecology of life on land (polar, forest and terrestrial ecology)</p>	2x 50 minutes	<p><i>Yoyo System Based Case</i></p> <p><b>Method</b> Discussion Case analysis</p>
6	<p><b>THE THEORY OF CLIMATE CHANGE</b></p> <p>Changes in climate trends are influenced by natural factors such as geology and astronomy as well as human factors in meeting their needs in the form of energy and consumption so that there is an increase in the amount of carbon dioxide in the atmosphere (climate change theory).</p>	2x 50 minutes	<p><i>Yoyo System Based -Case</i></p> <p><b>Method</b> Discussion Case analysis</p>
7	<p><b>THE ROLE OF HUMANS TO CLIMATE CHANGE</b></p> <p>Human activities in meeting their energy and consumption needs cause cases such as deforestation, acid rain, changes in vegetation cover, ocean acidification, ozone depletion and greenhouse gases that will affect the climate system and its elements.</p>	2x 50 minutes	<p><i>Yoyo System Based Case</i></p> <p><b>Method</b> Discussion Case analysis</p>
8	Presentation of cases and models made (Midterm test)		

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