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YOGYAKARTA STATE UNIVERSITY, INDONESIA
AND
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2017

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THE LITERACY OF SPATIAL THINKING ON GEOGRAPHY LEARNING MATERIALS FOR EQUIPPING STUDENTS WITH ENVIRONMENTAL UNDERSTANDING

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Abstract

This article presents aspects of spatial thinking in geography materials particularly intended for grade X of Senior high school which consists of seven basic competencies. The concepts of spatial thinking refer to Gersmehl and Gersmehl which consists of 11 concepts to understand the variations of objects, phenomena, potential, existing problems in the surface of the earth and attributes, character and its characteristics. The aspects of spatial thinking on Geography learning materials for grade X was resulted from the study through research and development that performed content and construct validation by an expert of geography material, an expert of evaluations, and the practitioner/teachers of geography. The validation was analyzed descriptively based on the categorization of the assessment score distribution. Results of the study show that aspects of spatial thinking on the materials of geography for grade X for each basic competence can be developed referring to the concept of Gersmehl and Gersmehl (2006) which include location, condition, connection, comparison, aura, territory, hierarchy, transition, analogous, patterns, spatial associations. These aspects are adapted on geography learning materials based on basic competences knowledge of geography (KD-3). The description of the integration aspect of spatial thinking on geography learning materials can be used as one of the bases for literacy of spatial oriented geography learning sources. The understanding of the concept of space, the cognitive processes that are carried out, and the use of tools/media representations in learning may enhance the students' understanding on environmental conditions comprehensively in real life.

Keywords: learning, spatial thinking, geography, environment

INTRODUCTION

Geography as a subject in Senior High School (SMA) tries to find and understand Indonesian spatial phenomena or symptoms with all its characteristics in diversity as a space of living of the nation identity and a change in science and technology. Alastair Bonnett, (2008: 5) states that geography emphasizes the existence of an integrated spatial linkage. I Made Sandy (1988: 6) adds that a holistic approach through the study of spatial, territorial, ecological and systems as well as historical describe and analyze the pattern structure, interrelated function and processes, interaction, interdependence and mutual relationship of a series of symptoms, appearance or occurrence of human life. The two statements are inline with the rational of geography presented in 2013 curriculum stating that geography includes aspects and earth processes, the causal relationship between spatial factors, humans and the environment directed to contribute to the development at a local, regional, and global level. Lambert and Morgan (2010: 73) focuses geography as a science that examines the location and organization of space activities of human beings on earth.

Conceptually, the idea is in line with the understanding of the spatial thinking concept. The characteristics of spatial thinking according to Jo and Berdnarz (2010: 50) include the ability that

involves knowledge and understanding of spatial concepts, applying knowledge with flexible capabilities, skills and habits of thinking to utilize tools, and provide a reason to solve problems and make decisions. Spatial thinking in geography can be invested systematically in the learning program as a multidisciplinary learning to provide an understanding of variety of objects, phenomena, potential, problems that exist on earth and its attributes, character and its types, especially the Indonesian physical circumstances and social interaction that exist.

The phenomenon in the field of education encountered by Sri Edi Swasono (2014: 33 and 62) tells that the awareness of geography students are still low, they mostly do not know nation identity space such as the boundaries of Indonesia from Sabang to Merauke and from Miangas to Rote Island. Sri Edi Swasono adds that the condition is a form of academic poverty which produces ambivalent human elite who have low awareness of ideology and nationality (2014: 63). Ketut Prasetyo (2013: 117) says that young people still do not know the names of the big island, the name of the big cities, and mountains in Indonesia. Ketut recommends the need to evaluate the method and approach of learning geography at high school level.

The data of the preliminary research which utilizes a questionnaire directed to 27 teachers of Geography in Yogyakarta on 1-4 October 2015 show that an average of 41% geography teachers rarely use spatial thinking component and an average of 16% never do so in the learning process in every basic competition of grade X. This condition implies that geography learning still emphasizes on the ability of conceptual and procedural of preliminary knowledge and do not yet lead to the factual and metacognitive aspects related to the materials being taught in Geography. Arum research results Darmawanti, et al (2013: 242) describes that the mastery of the material, structure, concept and mindset of scientific geography teachers (professional competence) in the city of Yogyakarta as a barometer of education in Indonesia is still 24% including in the category of poor.

Nursid Sumaatmadja (2001: 9) states that the elaboration of the concept, subject, and discussion of geography materials should be adjusted to the level of students' psychological development hierarchically. Mohan et.al (2015: 10) describes that geography is complex disciplines which focuses on the characteristics, relationships, and spatial patterns of human activity and nature. Geography teaches culture, geopolitics, natural systems, distribution and use of resources, and mapping of spatial data to better understand the world.

Geography curriculum in education should integrate aspects of spatial thinking in geography teaching materials. The essential materials of geography for grade X in the geography curriculum describes "Literacy and Skills of Geography" and "Physical Geography" which include: 1) A basic knowledge of geography and its application in everyday life, 2) The dynamics of Earth as a living space, and 3) The dynamics of geosphere and their impact on life.

The author identifies that the essential materials based on the scope of geography subjects for each Basic Competency (KD) knowledge consisting of seven points as presented in table 1. Based on the table 1, the number of Basic Competence knowledge and skills of Grade X consists of seven basic competencies which are varied therefore the general materials which are developed are also different. The gradation of the depth of material on every Basic Competence shows the thinking process from general to specific. The higher the grades, the more specific and deep of the materials will be taught.

Table 1. The main subjects of Geography Lesson at Senior High School

Basic Competency	The main subjects of Geography Lesson for grade X
3.1 and 4.1	• A basic knowledge of geography
3.2 and 4.2	• The steps of Geography research
3.3 and 4.3	• Introduction to Earth
3.4 and 4.4	• Dynamics of the lithosphere and its impact on life
3.5 and 4.5	• The dynamics of the atmosphere and its impact on life
3.6 and 4.6	• The dynamics of the hydrosphere and its impact on life
3.7 and 4.7	• The distribution of flora and fauna of Indonesia and the world

Heffron and Downs (2012: 17) emphasize two key perspectives to understand and study the geography, namely: spatial and the ecological perspective. They add that "Geography is concerned with the spatial dimension of human experience (space and place). ... Understanding spatial patterns and processes is essential to appreciating how people live on Earth. (2012: 17). This tells that geography is related to the spatial dimension of the human experience in the form of space and place. The author asserts that understanding spatial patterns and processes is vital to appreciate how human live on earth. Cresswell (2006: 30) points out that something that is absent in the spatial approach is a sense of values and meanings that can be embedded in mobility, so that the spatial construction is needed. The same opinion is stated by Hagget (2001: 763) and Bernadz (1994: 18) which mentions that "geography is an integrative discipline that brings together the physical and human dimensions of the world in the study of people, places, and environments", this definition implies that geography seeks to study nature, humans are integrative and mutual relationships between people, places, and environments. In this context, geography can be a bridge of thought and actualization of the social sciences to the natural sciences, in addition to understanding the dynamics of culture, society and economy. Inline with Heffron and Downs ideas and Cresswell criticism, the National Research Council's (2006: 116) informs that spatial thinking underlying intellectual structure of standard geography shows the possibilities and power for embedding spatial thinking in geography learning.

Some experts have tried to formulate a taxonomy of spatial thinking using different basis. Each has a basic taxonomy, for instance Gersmehl and Gersmehl (2007: 183) taxonomy is based on neurological mode, while Jo and Bednarz (2009: 72) developed a taxonomy based on spatial complexity. Jo and Bednarz, (2009: 73) asserts that in geography, the concepts such as location, distribution, region, pattern, distance and spatial association are considered important to be taught using spatial thinking. Some selection of spatial thinking concepts based on the experts are presented in Table 2.

Lee (2011: 17) argues that although the term and core concepts that they use are different, there are some similarities that are easy to find at each taxonomy of spatial thinking that they explain. The taxonomy formulated by Gersmehl and Gersmehl is simple and easy to be taught with the help of geospatial technologies, including the use of remote sensing imagery. The weakness is that there is no concept scale as an important concept in the context of spatial thinking. The concept of Golledge et.al (2008: 285-308) is more complete but it tends to direct the users on the ability of using maps

(cartography and GIS), such as buffer, overlay / dissolve, projections and transformations that can only be performed by utilizing GIS. Jenelle and Goodchild (2010: 1-13) concept seems to be simpler and different from the concept of Golledge, where the concepts of Jenelle and Goodchild are not only using a map. The concept of the environment, regional and spatial dependence can be understood through multiple media, such as maps, imagery, and field observations.

Based on a brief overview above, the authors intend to develop aspects of spatial thinking on geography teaching materials of grade X that can provide appropriate confirmation and comprehensive information on the quality of geography learning process at Senior high school. Spatial thinking as the basis for learning geography has not become a foundation for the development of geography learning design at Senior high school. Teachers still find difficulties in integrating spatial thinking on geography teaching materials that they teach. The fact needs to be thoroughly studied so that it may lead to the development of spatial thinking aspects of geography teaching materials for grade X of Senior High School.

Table 2. The concept of *spatial thinking from* Gersmehl and Gersmehl (2007), Golledge et al. (2008), Janelle and Goodchild (2009)

Gersmehl and Gersmehl	Golledge et al.	Janelle and Goodchild
Condition	Identity	Object and Field
Location	Location	Location
Connection	Connectivity	Network
	Distance	Distance
	Scale	Scale
Comparison	Pattern Matching	
Aura	Buffer	
Region	Adjacency, classification	Neighborhood and Region
Hierarchy		
Transition	Gradient, Profile	
Analogy		
Pattern	Coordinate	
	Pattern, arrangement, distribution,	
	Order, Sequence	
Spatial association	Spatial Association, Overlay/ Dissolve, interpolation, Projection, Transformation	Spatial dependence, spatial heterogeneity

Sources: Lee dan Bednarzd (2012: 17)

Scientific contributions of the study include describing the aspects of spatial thinking in geography teaching materials of grade X. The understanding of geography in the perspective of spatial thinking literacy becomes the theoretical foundation for developing the aspects of environments care. To make these expectations and to provide a common understanding of the mankind challenges in the future, the materials that should be considered and taught to future generations include being wise in using natural resources, fostering harmonious social relations, and promoting environmental preservation. Geography perspective on the dynamics of the physical

environment and the community will be viewed from the aspect of spatial integration and interdependence of good space between places or between scales. This perspective can be realized in the form of real or abstract (or representation) either visual, verbal, mathematical, digital, or mindset (cognitive).

RESEARCH METHODS

This paper is a research paper. This author uses Research and Development Method of Borg and Gall (2003: 782) consisting of ten steps which are simplified into three stages, namely the introduction, design and development, and implementation. The aspects of spatial thinking were validated by experts on Geography educational materials, measurement/evaluation, and geography teachers. Aspects that are validated consist of content validity and construct validity. They include: 1) the accuracy of the contents, 2) clarity of instructions, 3) clarity of structure and completeness of the instruments, 4) language, and 5) grammar, and 6) implementation.

RESEARCH FINDINGS

In the introduction stage, a preliminary study was conducted to collect grand theories and studies that are relevant with the assessment of spatial thinking on geography materials. After that, the framework constructs of spatial thinking aspects adopted from the study of Gershmel and Gershmel consisting eleven concepts were designed, then, these aspects were adapted to develop the geography teaching materials for grade X.

The initial drafts of the development of spatial thinking aspects in Geography for grade X materials were compiled by authors by considering the selection of the content through the collection of materials focusing on the content of the materials. The initial assessment of the products was carried out by employing six experts on learning evaluation and five experts on Geography subjects, namely lecturers of geography education department. The feasibility assessment was conducted by testing practitioners or 22 geography teachers who spread across 19 Senior High Schools.

Based on the assessment results of the products that have been designed, both experts state that the the draft of the assessment instruments for spatial thinking aspects on geography material is "feasible" to be tested or used in the field based on the revisions and the comments given ". The results of the above assessment were revised by considering the comments, suggestions and quantitative assessment. The conclusions of the two experts were followed up by testing geography teachers as a basis for developing an appropriate geography teaching model based on objectives stated in the curriculum.

The try out which was directed to 22 geography teachers from 19 schools aimed to measure the feasibility of product development of spatial thinking aspects on geography materials based on the accuracy of the content, clarity of questionnaire instructions, clarity of structure, completeness of evaluation models instruments, language and Grammar, and implementation. Based on categorization of data, the greatest relative frequency is 77.275%. The assessors state that the products developed belong to the excellent category, and other assessors 22.73% mostly say that the evaluation model of spatial thinking on geography materials is included in the category of "good" and there are no poor or even worst categories. This suggests that the products of spatial thinking aspects

on geography materials for grade X is "feasible for use" as one of the bases for developing learning resources and materials which are relevant with the current high school geography curriculum.

Aspects of Spatial Thinking on each basic Competence of Geography Grade X

National Research Council of the United States (2006: 12) and Jo and Bednarz (2010: 51) define spatial thinking as "a collection of cognitive skills comprised of knowing concepts of space, using the tools of representation, and reasoning processes". Some definitions of the spatial conception have constructive thinking, supported by three elements: the concept of space, the tools of representation and reasoning process. Uttal (2000: 285) states that the spatial depiction can be done through a cognitive reflex which influences the systems of symbols and is realized in the form of maps or spatial thinking abilities. Jones. et.al (2010: 359) describes further that the visualization of an object at different sizes require construction and deconstruction of mental ability to feel the actual visuals that may be more complex. The raw Information existing in the sensory experience (for example, see an object or photo) must be contextualized in terms of scale and relative orientation and then linked to the canonical representation.

The taxonomy of spatial thinking proposed by Gersmehl is used as an instrument due to the following reasons: first, it has been through a research on aspects of cognition and spatial thinking in which both have a relationship explicitly, clearly and are properly documented. Second, the purpose of spatial thinking taxonomy is to guide geography learning in a systematic and logical way. Third, Gersmehl taxonomy has been developed and expanded with examples of how these concepts are applied in the learning activities (Gersmehl 2008; Gersmehl and Anthamatten, 2008). The results of the analysis of integrating the concept of spatial thinking of Gershmel and Gershmel on Geography materials for grade X stated in the curriculum of 2013 is presented in the table 3.

The essence of spatial thinking in geography competence presented in Table above teaches spatial thinking for students to take a holistic approach through spatial representations of real-world objects in which there is information on the earth's surface, below the surface of the earth, waters, marine and lower atmosphere. The implementation of geography learning in spatial thinking perspective is not an addition to the curriculum, but rather as "a missing link" in defining the curriculum. National Academy of Sciences (NAS) states that the Integration and infusion of spatial thinking can help achieve existing curricular objectives. Spatial thinking is another lever that enables students to achieve a deeper and more insightful understanding of subjects across the curriculum (2006: 26). NAS (2006: 3-4) adds that the goal of integrating spatial thinking in learning to produce generations who (1) have a habit of spatial thinking, (2) practice spatial thinking using information they obtain, and (3) adopt a critical attitude through spatial thinking.

Table 3. The integrating the concept of spatial thinking of Gershmel and Gershmel on Geography materials for grade X stated in the curriculum of 2013

<i>Spatial Thinking skills</i>	Indicators						
	KD 3.1	KD 3.2	KD 3.3	KD 3.4	KD 3.5	KD 3.6	KD 3.7
Location	Show the description of absolute location and climatic relative phenomena	Show the right inset on the maps.	Write down the astronomical location of the research sites.	Show the latitude which consists of four seasons characteristics	Show the layer location of Si Al and Si Ma on the earth layers.	Show the atmospheric layer where the rain occurs.	Show the areas where there is a greatest evaporation process.
Condition	Explain the geographic approach on several phenomena of geography,	Show the profile graph correctly on the slope map..	Explain the overview of the research areas such as geography, social, economic, cultural, etc.	Explains the origin of the universe development using the existing theories.	Explain the type of rock that make up the earth's crust.	Explain an example of weather phenomena that occurs in the troposphere.	Explain the processes that occur in the hydrological cycle.
Connection	Explain a phenomenon of geography using the concepts of geography	Calculate the real distances on a map, For example the distance of town A and town B on the map is 4 cm, the scale of the map is 1: 40.000.	Explain the kinds of geography supporting knowledge about a particular map.	Show examples of evidence that the earth rotates.	Explain the process of recycling cycle phenomenon of magma rock, sedimentary, metamorphic rocks, and magma processing.	Explain the process of temperature changes that occur from the troposphere to the stratosphere.	Explain the effects of the evaporation amount that occurs in the sea on the high humidity in the air.
Comparison	Explain the phenomenon of geography in a certain region and other regions using geographic approach.	Describe the development of the industry correctly on the physical condition of two regions.	Explain a comparison of the measurement of air temperature in the rooms and in the out door.	Compare the process of forming each layer of the earth.	Look for differences of each rock type.	Compare the difference of the function of the layer (mesosphere) and (thermosphere) for life on the earth's surface.	Compare the differences in the occurrence of rain on land and at sea.
Influence	Describe the effects of	Describe the effects of recording	Describe example of Geography	Describe the effects of tectonic	Describe the effects of tektonism	Describe the effects of	Explain the effects of high and low

<i>Spatial Thinking skills</i>	Indicators						
	KD 3.1	KD 3.2	KD 3.3	KD 3.4	KD 3.5	KD 3.6	KD 3.7
	geography phenomenon somewhere on people's lives	time on the results of remote sensing.	studies in geography research methods in ecology approach.	plate movement on the formation of the earth's surface.	in a particular place on the morphology of the place.	temperature changes on the possibility of weather that happens.	evaporation of the precipitation produced.
Region	Give examples of country which has similar physical appearance.	Delineate land use patterns on the satellite image.	Explain the study of the same research problems between cities in Indonesia.	Give examples of areas which are part of the continental shelf and oceanic plates.	Classify the types of volcanoes in Indonesia based on the formation of volcanoes.	Find altitude differences that affect the characteristics of the layers of the exosphere and the thermosphere.	Explain the similarities between the characteristics of the territorial waters of the Pacific Ocean and the Atlantic.
Hierarchy	Explain the phenomenon of a country based on location, resources, etc. in regional life	Explain the benefits of satellite images for the everyday life.	Explains the stages of the study of geography	Explain the phenomenon of mountain formation in Java based on location, resources, etc.	Explain two movement of magma (magma intrusion and extrusion) associated with volcanism.	Explain the process of rain formation!	Explain various factors that influence the amount of rainfall in a region.
Transition	Show the morphological changes that occur as a result of erosion activity in the upstream and downstream	Show the size changes in forest area of Kalimantan in 2000 and 2010 based on the image.	Describe the changes in the city image within two periods recording.	Explain the morphological changes that occur as a result of tectonic plate motion in Sumatra and Java.	Show the processes that cause earthquakes occur at the Earth's surface.	Explain the differences and characteristics of clouds based on its height.	Show the comparison of the quality of ground water in rural and urban areas.
Analog	Identify the types of plants suitable to grow in areas with an altitude of over	Explain the symbols based on the appearance on the map.	Make a paper on the salt-producing areas in Indonesia and its	Shows other continents that have the same characteristics as	Identify the factors that affect weathering in various places.	Identify any country in the world which has a similar climate.	Describe the climatological and meteorological

<i>Spatial Thinking skills</i>	Indicators						
	KD 3.1	KD 3.2	KD 3.3	KD 3.4	KD 3.5	KD 3.6	KD 3.7
	600 meters dri dpal according to Junghun.		geographical conditions.	the volcano on the island of Java.			processes in the hydrological cycle
Pattern	Analyze the image, analyze settlement pattern which cluster on the sources of life.	Identify patterns that exist in the image stream. Eg trellis flow patterns exist in the structure of the folds.	Explain and draw a model of urban development for X city.	Analyze the Pacific fire ring track and find a point of earthquakes in the same period.	Analyze soil conservation techniques based relief	Explain and describe the process of rain formation	Explain the short hydrologic cycle and the factors that influence it.
Spasial association	Show a map symbol on the flow pattern of rivers and lakes in the same area	Associate things that show the appearance of the harbor.	Find the cause of flood in the X region and the evidence on the ground.	Look for the distribution pattern of volcanoes in Indonesia and the world by using the symbol of active volcanoes in the world.	Find different types of soil and group them into 12 classes of soil texture!. (Sand, loam, clay, dust)	Explain the examples of phenomenon that occurs in the troposphere.	Explain a comparison of the water needs in the agricultural areas and industrial areas.

Sources: results of analysis

The Table implies that the Indonesian spatial context which presents the diversity of Earth's surface area as a place of living for human with natural and social aspects as well as the interaction, interrelations between the aspects of spatial thinking become an object that must be understood by the students. They can use a multidisciplinary approach by employing spatial perspective which will result in geographic areas that have difference characteristics at the same object, phenomenon, pattern, problems, potentials, which exist on the earth. Indonesia, with all its characteristics and diversity is understood as a space of the nation identity and a change in science and technology. The generated content of spatial thinking suggests that education must recognize the close relationship between action and thought, between experiments and reflections.

Based on the perspective above, the topics or materials of geography do not only introduce the scope, the object of study, principles, concepts, and approaches of geography, but seek to provide spatial thinking literacy and geography skills that include basic knowledge of geography and its application in everyday life in each environment. The environmental interactions which include the condition of Indonesia, the distribution of Indonesia's natural resources, and natural disaster mitigation and adaptation based on the value of local knowledge and sustainable development must be possessed by learners when learning geography. Other abilities that are expected include applying spatial thinking for students in order to be able to think critically and are able to overcome problems in their respective communities in relation with a room change, damage and impact of conservation efforts and various changes due geosphere processes both in the context of local, national, and global. Students are able to create and update the physical environment and the social environment as a resource that can be utilized as much as possible for human welfare which is managed wisely by upholding the values of tolerance towards cultural diversity of the nation. The literacy of information, technology, media, and communication can be applied as geography analytical tool for decision making both at the local, national, and international levels. At the end, students can collaborate and communicate to develop relations (connections) in between the space either in the form of people, goods, and services in national and international environmental to demonstrate patriotism, proudness as Indonesian, and responsible for the integrity of the Republic of Indonesia based on Pancasila and the 1945 Constitution.

CONCLUSION

The indicators that show the evidence of spatial thinking in geography materials of grade X for each basic competency can be developed by adapting the concept of Gersmehl and Gersmehl (2007). The aspects of materials can be adapted based on geography basic competence, so that aspect of spatial thinking for each material is different. The results of this development can be used as one of the bases of geography spatial oriented learning resources as the core identity and effort to prepare the learners who know, understand, and provide solutions to the problems of the environment.

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