Evaluating Disaster Instructional Material Questions in Geography Textbook: Using Taxonomy of Spatial Thinking to Support Disaster Preparedness

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S Ridha[1,2*], S Utaya[3], S Bachri[3], B Handoyo[3]

[1]Doctoral Student of Department of Geography Education, Postgraduate of State University of Malang Indonesia, Jalan Semarang No. 5 Malang,
[2]Department of Geography Education Sekolah Tinggi Keguruan dan Ilmu Pendidikan Al-Washliyah Banda Aceh, Indonesia, Jalan Al-washliyah No.1 Banda Aceh
[3]Department of Geography Education, Faculty of Social Science, State University of Malang Indonesia, Jalan Semarang No. 5 Malang

[*]E-mail: syahrul.ridha.1607219@students.um.ac.id

Abstract. This paper discusses whether instructional material questions about disaster in geography textbooks contain three components of spatial thinking, namely: 1) concepts of space, 2) tools of representation, and 3) processes of reasoning. The taxonomy of spatial thinking is used to evaluate the instructional material questions about disaster in geography textbook of senior high school in Indonesia. A survey was conducted to select geography textbooks that were most dominantly used in senior high school. Four geography textbooks with curriculum 2013 were chosen and evaluated. These textbooks are used as learning resources by majority of teachers and standardized by the National Education Standards Agency (BSNP).Then, the books were reviewed in instructional material questions about disaster and the questions were evaluated. Evaluation is done by coding technique using taxonomy of spatial thinking. The evaluation result showed that spatial concepts of instructional material questions about disaster were still classified as low, even 73 percent of questions was designed without using concepts of space (non-spatial). Besides, the majority of representation tools were not used. From 189 questions evaluated, only 27 questions or 14 percent used tools of representation. In addition, the majority of reasoning processes was at the average level (processing) or 47 percent. The processes of reasoning should be run with student's activities to obtain high level cognitive processes, for example by create maps and designing an area for disaster evacuation. In brief, from spatial perspective, this study revealed that instructional material questions about disaster in geography textbooks have not supported preparedness in facing disaster. Therefore, teachers and textbook writers need to develop instructional material questions about disaster from spatial perspective to support disaster preparedness.

Keywords: evaluating, disaster instructional material, questions, spatial thinking, disaster preparedness.

1. Introduction

Spatial thinking is a process of cognitive ability [1]. Spatial thinking is essential part in geography education because it can help improve the ability to represent, plan, analyze and design an area and have an ability to connect between physical and human being [2]. Spatial thinking consists of three components, namely concepts of space, using tools of representation, and processes of reasoning [3], [4]. Those three components have a relationship with one another. In learning geography, spatial thinking is the main foundation in geography skills [5]. This is because each component of spatial thinking influences each other. In addition, spatial thinking is important to improve understanding of location, distribution, interrelation of geosphere phenomena and the use of geospatial technologies (GST), such as GIS, remote sensing and GPS (global positioning systems) [1]. The result of previous study evaluating questions in geography textbooks in senior high school indicated that the questions

are dominated by relatively low spatial concept questions, the spatial representation provided in geography textbooks is not combined with activities to obtain higher cognitive processes [3]. The result of another study showed that questions in geography textbooks at university have higher spatial level than questions in geography textbooks in senior high school [6]. The questions designed at university stimulate students to think in higher level and lead to problem solving.

Based on the result of those studies, the purpose of this study is to analyze the content of components of spatial thinking in instructional material questions about disaster, namely: concepts of space, tools of representation, and processes of reasoning. Therefore, it is important to evaluate instructional material questions about disaster with spatial thinking perspective to support disaster preparedness in senior high school students. Disaster preparedness must be measured in learning geography in senior high school. The measurement aims to find out to what extent students have been prepared for disaster in school. As a result, it is necessary to know whether questions in instructional material about disaster include three components of spatial thinking or not? This question can be answered by evaluating instructional material questions about disaster in geography textbook in senior high school using taxonomy of spatial thinking. Thus, instructional material questions about disaster can be identified from spatial perspective to know their lacks. Table 1 below shows taxonomy of spatial thinking used to evaluate instructional material questions about disaster.

Table 1. Taxonomy of spatial thinking

Components of spatial thinking		Taxonomy
Category	Subcategory	
1. Concepts of space	Non-spatial	-
	Spatial primitives	Place-specific, Identity, Location, Magnitude
	Simple spatial	Distance, Direction, Connection & Linkage, Movement, Transition, Boundary, Region, ShapeReference, Frame, Arrangement Adjacency, Enclosure
	Complex spatial	Distribution, Pattern, Dispersion & Clustering, Density, Diffusion Dominance, Hierarchy & Network, Spatial Association, Overlay, Layer, Gradient, Profile Relief, Scale, Map Projection, Buffer
2. Using tools of representation	Use	Map, Diagram, Chart, Graph, Photo
	Non-Use	-
3. Processes of reasoning	Input	Name, Define, List, Identify, Recognize, Recite, Recall, Observe, Describe, Select, Complete, Count, Match
	Processing	Explain, Analyze, State causality, Compare, Contrast, Distinguish, Classify, Categorize Organize, Summarize, Synthesize, Infer, Make analogies, Exemplify, Experiment, Sequence
	Output	Evaluate, Judge, Predict, Forecast, Hypothesize, Speculate, Plan, Create, Design, Invent, Imagine, Generalize, Build a model, Apply a principle, Complex

Source: [Jo I, Bednarz S W. and Metoyer S. 2010. Selecting and Designing Questions to Facilitate Spatial Thinking,Geogr. Teach., vol. 7, no. 2, pp. 49–55.]

The first component of spatial thinking is concepts of space. Concepts of space is a form of knowledge to understand location, distance, pattern, affordability, morphology, association, spatial relationship of geosphere phenomenon. To understand spatial concepts, concepts of space are divided

into four subcategories, namely non-spatial, spatial primitives, simple-spatial, and complex-spatial [7]. Questions categorized as non-spatial are questions that do not contain the component of spatial thinking. For example, how many people come from Pidie District in Banda Aceh City? Spatial primitives are the lowest spatial concepts that use the concept of location, place-specific, identity, and magnitude in the questions [6]. For example, what province is located between East Java Province and West Nusa Tenggara Province (NTB)? This question can be identified as a specific place between East Java and NTB. Simple-spatial is a higher concept of space than spatial primitives based on concepts and distribution, distance, direction, connection and linkage, movement, transition, boundary, region, shape, reference frame, arrangement, adjacency, and enclosure [6]. For example, in what climate regions can the tundra-forest be found? Complex-spatial is the highest spatial concept based on spatial distribution [8], including distribution, pattern, dispersion and clustering, density, diffusion, dominance, hierarchy and network, spatial association, overlay, layer, gradient, profile, relief, scale, map projection, and buffer [9]. For example, where is the best place in Banda Aceh to build a tsunami evacuation tower with consideration of population distribution and land available on an urban planning map? This question uses the concept of spatial distribution and association. This will be evaluated as complex-spatial.

The second component of spatial thinking is using tools to represent information (using tools of representation). The tools include maps, diagrams and graphs [8]. The third component is processes of reasoning. Processes of reasoning is an activity of reasoning on objects mapped. Reasoning is an activity of interpreting information contained in a map to be used by students as an information, such as distribution of animals and plants in Indonesia. Interpretation is done by mentioning, explaining, and analyzing objects on the map. The reasoning process is divided into three categories, namely input, processing and output, in which these three subcategories have different taxonomies [6].

Disaster preparedness not only needs the ability of organization, but also needs spatial ability as basic foundation in making decision to deal with disaster [9]. The important goal of learning disaster preparedness from spatial perspective is the provision of spatial concepts that students need when they face disaster. Thus, instructional material questions are very important to contain spatial thinking components to support disaster preparedness.

There are three key elements of spatial thinking that can be used in disaster preparedness [9], namely: 1) concepts of space, students understand about spaces and directions that are around them, such as point, region, and distance, in which it becomes an important object in building spatial concepts . For example, when a disaster occurs, students know where they have to run, where the shelter buildings are located. 2) Knowing about representation of space, a map becomes a space representation tool that must be understood, both two and three dimensions of region. Students must be able to connect an abstract representation on the map with the real world. For example, colour on a map, students must be able to recognize their environment, such as where the danger zone is, how wide is the submerged area and how much the rainfall occurs. These questions can be described on the map to represent the actual environmental conditions. 3) Knowing about processes of reasoning, knowing about reasoning process leads to problem solving through spatial perspective using various cognitive skills and knowledge. For example, how to determine a good evacuation route during tsunami disaster and where the safe meeting place is when an earthquake occurs. These questions require good reasoning skills to understand. Thus, it has to be taught to students.

Students need to know those three elements of spatial thinking as a knowledge that must be provided for disaster preparedness. The knowledge can be implicated through the design of spatial thinking instructional material questions about disaster, namely using the component of spatial thinking in the questions. The questions can be combined into textbooks as an student's exercise in the form of assignment questions, multiple choices, and essays. Thus, students can train themselves to face disasters with spatial abilities.

2. Method

This study evaluates instructional material questions about disaster in geography textbooks used in high school. The textbooks was chosen by conducting a survey in all senior high schools in Banda Aceh in order to select the dominant geography textbooks used in teaching-learning process. Then, the dominant books used were reviewed based on instructional material questions about disaster. The survey result showed that there are four textbooks mostly used as a source of learning in learning geography. The four books are: 1) Geografi Untuk SMA/MA Kelas XI Berdasarkan Kurikulum 2013 Edisi Revisi [10], 2) Jelajah Dunia Geografi SMA/MA Kelas XI Kurikulum 2013 Revisi Kelompok Peminatan [11], 3) Mengkaji Ilmu Geografi Untuk Kelas XI SMA dan MA Kurikulum 2013 Edisi Revisi [12], and 4) Buku Siswa Geografi Untuk SMA/MA XI Peminatan Ilmu-ilmu Sosial [13]. Besides, these books were also standardized by the National Education Standards Agency (BSNP). Data collection was done by coding technique. Coding is used to identify the use of three components of spatial thinking in instructional material questions about disaster. Then, coding results are showed in percentage of relative frequency table.

The questions evaluated were assignments and practice questions at the end of books' chapter. The questions of assignment were in the form of individual and group assignments, while the questions of practice were in the form of multiple choice and essay. Table 2 below shows the number and location of questions evaluated.

Table 2. Location of questions in instructional material about disaster

Questions Location	Instructional Material A	Instructional Material B	Instructional Material C	Instructional Material D	Total
Assignment	17 (23%)	15 (27%)	2 (9%)	10 (25%)	44 (23%)
Multiple Choice	26 (36%)	29 (53%)	10 (48%)	12 (30%)	77 (41%)
Essay	30 (41%)	11 (20%)	9 (43%)	18 (45%)	68 (36%)
Total	73 (100%)	55 (100%)	21 (100%)	40 (100%)	189 (100%)

Coding is specifically focused on component of spatial thinking (Figure 1): 1) classifying questions into spatial concepts, namely non-spatial, spatial primitives, simple-spatial, and complex-spatial. 2) determining the use of representation tools on questions, namely use and non-use. 3) classifying cognitive processes on questions, namely input, processing and output [3]. Table 3 below shows an example of coding questions using taxonomy of spatial thinking.

Table 3. Example of questions coding

Questions	Categories		
	Concepts of space	Tools of representation	Processes of reasoning
Non-spatial thinking questions - List examples of senior high school student participation in natural disaster management through local wisdom and modern technology.	Non-spatial	Non-use	Input
Spatialthinkingquestions - Create a map/ plan of disaster evacuation route in the area where you live. Determine the gathering location (assembly point) and the fastest road to reach the evacuation location.	Complex spatial	Use	Output

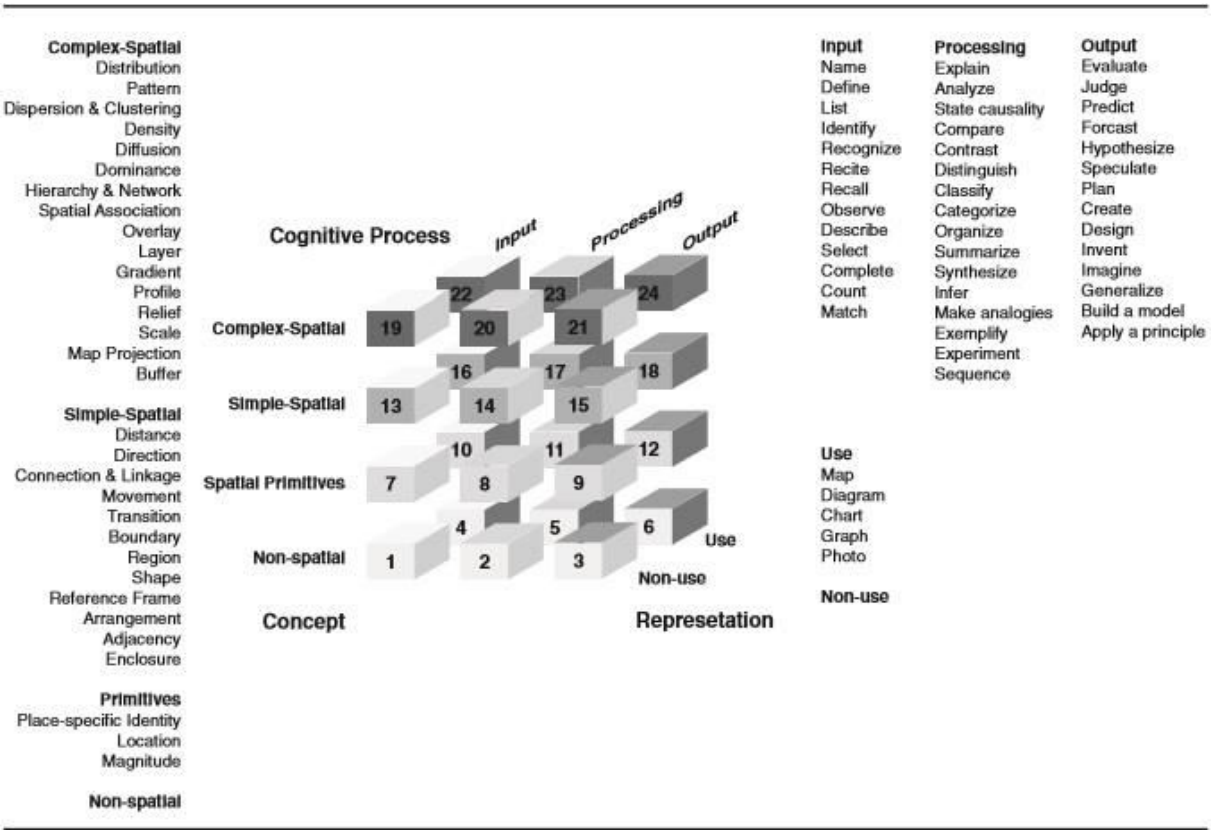

Figure 1.Taxonomy of spatial thinking used in evaluating questions in instructional material about Disaster. Sources: [Jo I and Bednarz S W. 2009. Evaluating Geography Textbook Questions from a Spatial Perspective: Using Concepts of Space, Tools of Representation, and Cognitive Processes to Evaluate Spatiality, J. Geogr., vol. 108, no. 1, pp. 4–13.]

3. Results and Discussion

Spatial thinking in this study is defined as one form of thinking that combines some cognitive skills [14]. The combination includes three components, namely concepts of space, using tools of representation and processes of reasoning. These three components should be used in a complex way at high level, for example, concepts of space (complex-spatial), tools of representation (use) and processes of reasoning (output). Furthermore, the result of instructional material questions evaluation about disaster is showed by following three components of spatial thinking. Those three components are explained as follows.

Concepts of space

The spatial concept contained in 189 instructional material questions is non-spatial as much as 73 percent. While, the other spatial concepts used are follows: spatial primitives with 12 percent, simple-spatial with 8 percent and complex-spatial with 7 percent. The imbalance in the use of spatial concepts in these questions is caused by the preparation of questions not based on spatial thinking. Table 4 below shows the percentage of spatial concepts in instructional material questions about disaster.

Table 4. Percentage of spatial concepts

Subcategory	Disaster Instructional material A	Disaster Instructional material B	Disaster Instructional material C	Disaster Instructional material D	Total
Non-spatial	60 (82%)	41 (74%)	16 (76%)	20 (50%)	137 (73%)
Spatial primitives	5 (7%)	3 (6%)	1 (5%)	14 (35%)	23 (12%)
Simple-spatial	6 (8%)	4 (7%)	3 (14%)	3 (7,5%)	16 (8%)
Complex-spatial	2 (3%)	7 (13%)	1 (5%)	3 (7,5%)	13 (7%)
Total	73 (100%)	55 (100%)	21 (100%)	40 (100%)	189 (100%)

The spatial concept used in instructional material questions about disaster should be at high level, namely complex-spatial. This complex-spatial level aims to make students able to improve disaster preparedness. It can be seen from the ability to understand the distribution of disaster-prone locations, the ability of planning disaster evacuation routes with overlay technique andthe ability to save themselves by going to the safest building to seek protection. In addition, textbook writers and teachers must concentrate on the sustainability of development of instructional material questions about disaster at high spatial level.

Using tools of representation

The use of tools means using map, diagram, chart, graph, and photo [15]. The majority of representation tools is not used in instructional material questions about disaster. From 189 questions evaluated, there are 162 questions or 86 percent not using tools of representation and only 27 questions or 14 percent use tools of representation. This number shows that there is a lack of instructional material questions about disaster that must be corrected. Table 5 below shows the percentage of the use of representation tools in instructional material questions about disaster.

Table 5. Percentage of using tools of representation

Subcategory	Disaster Instructional material A	Disaster Instructional material B	Disaster Instructional material C	Disaster Instructional material D	Total
Use	6 (8%)	10 (18%)	1 (5%)	10 (25%)	27 (14%)
Non-use	67 (92%)	45 (82%)	20 (95%)	30 (75%)	162 (86%)
Total	73 (100%)	55 (100%)	21 (100%)	40 (100%)	189 (100%)

Using tools of representation in disaster preparedness is important to be considered in compiling instructional material questions about disaster. It can help students to understand visualization of images on map, both two-dimensional and three-dimensional maps with the real world. Besides, it can also help students to interact with maps by combining the tools of representation into instructional material questions about disaster [16]. For example, by asking a few questions, where is the heat/danger zone? How many areas are flooded and where? How is the weather forecast for the coming days? [9].

Processes of reasoning

Spatial thinking is the ability of cognitive skills that require complex reasoning [17]. Giving information through high-level cognitive processes becomes one of the reasoning complexity measure, for example, the student's activities for creating thematic map and plan in using land of region. Besides, it can be seen from the way students determine the best evacuation route during tsunami and flood disaster. However, the evaluation results hows that the majority of cognitive process in instructional material questions about disaster is average at 47 percent in the processing subcategory, low-level reasoning at 39 percent in the input subcategory, and high-level of reasoning only at 14 percent. Only 27 questions out of 189 direct students to high-level reasoning or output which includes

creating, planning, and predicting about disaster on people's lives. Table 6 below shows the percentage of reasoning processes in instructional material questions about disaster.

Table6. Percentage of processes of reasoning

Subcategory	Disaster Instructional material A	Disaster Instructional material B	Disaster Instructional material C	Disaster Instructional material D	Total
Input	31 (42%)	25(45%)	9 (43%)	9 (22%)	74 (39%)
Processing	40 (55%)	14 (26%)	11 (52%)	23 (58%)	88 (47%)
Output	2 (3%)	16 (29%)	1 (5%)	8 (20%)	27 (14%)
Total	73 (100%)	55 (100%)	21 (100%)	40 (100%)	189 (100%)

Complex reasoning is needed by each student for disaster preparedness, especially for students who live in disaster-prone locations, such as beaches, earthquake, landslide and flood prone areas. It must be supported by education systems, such as curriculum support, teaching and learning material in schools are based on spatial thinking in disaster learning. In addition, teaching materials should contain questions with complex reasoning in input, processing and output. These three levels of questions must be integrated into instructional material questions about disaster.

A good question about disaster is a question containing component of spatial thinking in high-level, covering complex-spatial, using tools of representation and processes of reasoning that can trigger high-level cognitive (output). The complex-spatial level is a process of thinking about spatial distribution. For example, where is the best place in Lampuuk Beach, Aceh to build a coastal disaster-prevention forest by considering the distribution of population and land available on the map? Then, create a new map for tsunami disaster as a plan to minimize its effect. This question shows that the concept of spatial distribution and association is used to minimize tsunami damage. In addition, in the process of learning students create map related to a plan for minimization of tsunami damage. Thus, questions with complex-spatial components and using tools of representation and output can train students for disaster preparedness from a spatial perspective.

4. Conclusion

Spatial thinking is one of the disaster preparedness benchmarks in disaster education because everyone is absolutely thinking about the space where he is, where to run and where to shelter when facing a disaster. Therefore, spatial thinking needs to be integrated in learning, including by designing instructional material questions about disaster with spatial thinking perspective. Generally, evaluation results show that the spatial concept of instructional material questions about disaster is still classified as low, even 73 percent of questions is designed without using spatial concepts (non-spatial). Besides, the majority of representation tools were not used. From 189 questions evaluated, only 27 questions or 14 percent used representation tools. Furthermore, the majority reasoning process was at average level (processing) or 47 percent. Therefore, reasoning process should be managed with student activities to obtain high level of cognitive processes, for example by creating map and designing an area for disaster evacuation. Good instructional material questions about disaster is questions that contains complex spatial thinking components, including using complex-spatial with high-level concept, interpretation tools and reasoning processes that can trigger high cognitive levels of students. The question that only asks students to memorize information is not enough to facilitate student's spatial thinking skills and disaster preparedness. Therefore, instructional material questions about disaster which contain three components of spatial thinking needs to be developed in geography textbook.

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