Spatial Thinking and Decision-Making Abilities to Learn About Disaster Preparedness

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Abstract: Disaster preparedness is one concern in Indonesia for natural disasters have frequently occurred in the country, both geologically and environmentally. Disaster preparedness focuses on activity series which are related to organizational ability, spatial thinking, and decision-making abilities. However, the two latter are still unconcerned. This study aims to improve disaster preparedness through spatial thinking. It is an action research, with the subject of 32 high school students who were studying geography lesson. The data were analyzed using descriptive statistical techniques. The study results are: (1) there was an increase in students' knowledge about disasters with the classical completeness of 92%, proving the effectiveness of the learning process (2) It is easier for students to understand the concept of disaster through spatial thinking. Spatial thinking includes three components, namely: (a) the spatial concept as the space and direction, such as points, regions, distances, which are vital during disaster; (b) tools of representation, such as maps of an area as representations of the real-world; (c) the process of reasoning for problem-solving through a spatial perspective by using a variety of cognitive skills and knowledge. Therefore, schools need to facilitate teachers to implement spatial thinking-based disaster education in preparing young people to face disasters.

Keywords: Spatial Thinking, Decision-Making Abilities, Disaster Preparedness

1. Introduction

Natural hazards can occur in various forms that affect people in different ways and become disasters after impacting the community [1]. It includes physical activities, phenomenon, or human activities that potentially cause injury, death, property damage, economic and social disruption, or environmental degradation [2]. Thus, the society need to be prepared with the knowledge of disaster preparedness to decrease the risk [3].

Although development disaster preparedness is an important element in dealing with natural hazards, it is not easy to do because it involves people's behavior, cultures, mentality, and discipline [4], [5]. The measurement of disaster preparedness include (1) knowledge of the actions to take when a disaster occurs, (2) knowledge of how to do the actions, and (3) the availability of the tools for disaster preparedness [6]. A community is regarded to have a good preparation if this three things have been fulfilled [5]. Thus, disaster preparedness is not only for the adults, but also for all ages; ranging from toddlers, adolescents, adults, and the elderly. Furthermore, disaster preparedness is grouped into five parameters, namely disaster knowledge, policy, emergency planning, warning systems, and resource mobilization [7], [5].

Knowledge becomes the basis for an individual's awareness and actions; especially when disasters occur, community knowledge is crucial in making decisions [8]. The community need know the types of threats that occur in their area, for example the geological threats...
such as volcanic eruptions, tsunami, earthquakes; environmental threats such as forest fires flood, landslide, and storm. It is also necessary to know the type of threat such as the cause, the strength of the threat, the speed, the duration, and the high risk areas.

Thinking is mental processes that enables human to effectively arrange information to create concepts as well as to engage in problem-solving, reasoning, and decision making [9], [10]. Most of the works requires various forms of thinking, namely logical, mathematical, visual, or verbal thinking [9]. Preparing and reacting to disasters combine various forms of thinking and existing knowledge skills. Spatial thinking, thus, is a key element in developing survival strategies during disasters [10]. Spatial thinking is a combination of three constructive elements, namely the concept of space, tools of representation, and the process of reasoning [9], [11]. Understanding the concept of spatial means understanding location, distance, region, pattern, spatial association, distribution, and relief [12]. The tools of representation include maps, diagrams, charts, and photos. While, the process of reasoning is related to cognitive levels such as identify, describe, list, explain, analyze, evaluate, plan, and create [13]. The integration of spatial thinking in disaster education is important to develop the spatial preparedness either before disaster or during the disaster [10], [8].

Various studies on disaster preparedness have been carried out. They mostly focus on reviewing the location of schools that are safe from disasters, disaster management, and disaster education. Sakurai et al., (2018) proposes to reactivate disaster preparedness activities in schools and highly recommends the local government’s policy support in ensuring its implementation in all schools in Banda Aceh [14]. Other researchers suggest to put in the schools’ annual plan (including conducting tsunami evacuation drilling at least once/year) and in the school budgets for conducting disaster preparedness activities. However, there is a limited number of research on improving disaster knowledge by using spatial thinking in schools. Thus, this research focuses on the use of spatial thinking ability on improving disaster preparedness.

This study was conducted in Banda Aceh because the city has a high level of tsunami disaster vulnerability [14]. It is estimated that the tsunami arrival time for Banda Aceh City is 35 minutes [15]. Having faced a tsunami on December 26 in 2004, Banda Aceh citizen need to be able to reduce the risk of a tsunami disaster [3], [16]. For information, Tsunami and Disaster Mitigation Research Center (TDMRC) of Universitas Syiah Kuala has implemented the Disaster Preparedness School (Sekolah Siaga Bencana/SSB) program in Banda Aceh City [17], [16]. However, students were found to have low knowledge about disasters, including the high school students [18]. This due to SSB was not optimally implemented in all schools and lack information sources of disasters [14], [19]. Therefore, it is important to reveal new ways of increasing disaster knowledge, especially to the young people [20]. Based on the problem above, the purpose of this study is to increase knowledge about disaster through spatial thinking for disaster preparedness.

2. Method

2.1 Research Design
This study uses a classroom action research approach. Action research is class-based research that is carried out systematically to solve problems [18], [21]. This research was conducted in five steps, namely (1) identifying problems, (2) planning learning, (3) Actions, (4) observing and analyzing results, and (5) reflection [21], [22]. Figure 1 shows the stages of the study.
The stages of the research conduct were identifying problems, planning of learning, conducting activities, analyzing learning outcomes, and reflecting (evaluating). First, the identification of problems that exist in the classroom related to the level of students' knowledge of disasters and whether students use spatial thinking to increase knowledge about disasters. Then, the learning was planned based on the problem. Following the plan, actions were taken to increase disaster knowledge. The analysis was done to measure the learning outcomes by seeing the classical completeness. The results of the analysis were then reflected to decide further steps.

2.2 Data Collection
The study was conducted at Adiwiyata School, namely SMAN 4 Banda Aceh. An Adiwiyata School is an environmental and cultural care school and that aims to become an institution which is able to adapt and carry out environmental conservation and sustainable development for the present and future generations [23], [24]. This is the basis for selecting the SMAN 4 Banda Aceh as the object of this research. The school is located at 5°33'58.01"N 95°20'36.89"E and is 3.84 Km from the beach. Also, SMAN 4 Banda Aceh was an inundation area of the tsunami in the 2004 [14]. The research subjects were 32 high school students who were studying geography subjects.

2.3 Data Analysis
Data were analyzed with descriptive statistical techniques. This is to see the increase in student knowledge for disaster preparedness and decision making abilities through spatial thinking. The learning outcomes were measured to determine classical completeness. Classical completeness measurement aims to find out the success of learning in class. In this study, learning success was not seen from individuals, but from the whole class. To calculate the classical completeness, the formula used was as follows [25].

\[ K = \frac{\sum ni}{N} \times 100 \]

Description:
- \( K \) = classical completeness
- \( \Sigma ni \) = the number of students who success
\[ N = \text{the number of total students} \]

The category of the study results was seen from criteria as in Table 1 below.

| Rate          | Category       |
|---------------|----------------|
| 90% - 100%    | Very effective |
| 80% - 89%     | Effective      |
| 70% - 79%     | Quite effective|
| <69%          | Less effective |

Table 1. Completeness Rate Completion

3. Result and Discussion

This part begins with a description of the measurement of students’ learning outcomes and spatial thinking activities that enhanced students’ knowledge on disasters. Learning outcomes were obtained from the test on each of the activities. Spatial thinking activities are carried out by interpreting satellite images and analyzing maps. These thinking activities become the basis for decision making for disaster preparedness.

3.1. Measurement of Student Learning Outcomes

Measurement of learning outcomes can be defined as an activity of comparing the object of learning outcomes with the measurement scale set in the instrument to describe the quality of learning outcomes (changes in behavior) [27]. Measurements were made through a set of tests containing questions that have a component of spatial thinking regarding disasters. In learning about disaster at schools, it is recommended to use questions that contain component of spatial thinking to improve students' understanding of disasters [28].

Measurements were made twice, namely during the first action and the second action. The measurements were aimed to see the students' knowledge in each action that requires spatial thinking. Table 2 shows the results of the measurement of the first action.

Table 2. Learning outcomes of the first action

| Grade          | Criteria Learning Mastery | Completeness | Effectiveness |
|----------------|---------------------------|--------------|---------------|
| XI-Social Sciences | 75                        | 15 52        | Less effective|

Table 2 shows an ineffective learning. This can be seen from the classical completeness which is 52%. This ineffectiveness was due the students were not accustomed to carrying out learning with spatial thinking activities. Based on these results, the second action was carried out. Learning outcomes in the second action are shown in the following Table 3.

Table 3. Learning outcomes of the second action

| Grade          | Criteria Learning Mastery | Completeness | Effectiveness |
|----------------|---------------------------|--------------|---------------|
| XI-Social science | 75                        | 29 91        | Very effective|

Table 3 shows a very effective learning outcome, which is 91%. This effectiveness was influenced by the engagement of learning with spatial thinking activities. After learning was
done, on the interview students agreed the learning was interesting. The activities could increase learning motivation; leading students to easily understand materials about the disaster.

3.2. Spatial Thinking to Improve Disaster Knowledge

Spatial thinking activities were carried out through geospatial technology [29]. Geospatial technologies include geographic information systems, remote sensing, and global positioning systems (GPS) [30]–[32]. In addition, Google Earth is currently used in learning to improve understanding of geography education [33]. In the geography curriculum at high school level, disaster learning includes geography to learn about disasters. In this study, the geospatial technology used was GIS and Google Earth [34]. GIS was used to make a map of the city of Banda Aceh and locations submerged by the 2004 tsunami and Google Earth was used to find objects through images on Google Earth via mobile android.

Spatial thinking is a form of knowledge and skills to use the concept of space (distance, orientation, distribution, and association), to use the representation tools (maps, graphs, and diagrams), as well as the reasoning processes (cognitive strategies to facilitate problem-solving and decision making) to arrange problems, find answers, and express solutions to these problems [9], [35]. Spatial thinking becomes a new foundation that can be used in developing geography skills [36]. The use of digital map technology on smartphones can be accommodated by these three components. Spatial concepts can be detected through distance, location, interrelation of a place. Detection can be done with technology in the form of Google Maps on mobile. Reasoning objects in the Google Maps in the form of mentioning, making a new map, explaining and evaluating.

In addition to Google Maps, Google Earth is also a software program from geospatial technology that is popular today [34], [37]. Google Earth is a virtual globe, a program that provides interactive three-dimensional (3D) representations of the earth [31]. Three-dimensional representation becomes a tool for objective reasoning. This relates to spatial thinking. The link is Google Earth as a tool for earth representation to strengthen spatial thinking skills. Google Earth has great potential to improve geography learning methods and help students to develop other abilities [33].

Nowadays, smartphone usage is very popular among students. The technology that is available on mobile devices can be used to improve students' learning abilities during field trips [38], [39]. Thus, it should be utilized in learning geography and disaster. The use of Google Earth on smartphones is a reinforcement of spatial thinking skills. Existing studies reveal that Google Earth effectively develops students' skills in using technology [33], [37], [31]. This is important for students to learn how to use geospatial technology in solving spatial problems. Geospatial technology can produce outputs in the form of maps. Maps can be used by students in learning geography, both digital maps, and analog maps. The use of maps in learning is an implication of the component of spatial thinking, namely the use of tools of representation [40].

An important objective of the learning plan on disasters is to enable school children to learn about spatial concepts that they need to use when dealing with disaster. Disaster preparedness is not only about the ability of disaster management but also the spatial ability that becomes the foundation in decision making when facing a disaster, for example knowing the location of a rescue building in the event of a tsunami disaster [28]. The objective of learning disaster preparedness from a spatial perspective is that through debriefing about the spatial concepts, students know what to do when facing a disaster [8]. With geospatial technology learning, it is important to include spatial thinking components to support disaster preparedness.
Spatial thinking is a form of thinking that combines cognitive skills [9]. Spatial thinking is a combination of building cognitive skills through the concept of space, the use of representation tools and the reasoning process [32]. Regarding disaster preparedness, three key elements of spatial thinking can be used, namely [10], [18].

1) Concept of space. Students’ understanding of space and the direction around them, such as points, regions, distances which are important objects in developing spatial concepts. For example, when a disaster occurs, where should I run? Where are shelters provided?

2) Knowing about the representation of space. Maps as a space representation that must be comprehended, both two-dimensionally and three-dimensionally. Students must be able to connect abstract representations on the map with the real world. For example, on coloring on the map, students must be able to recognize the environment, such as where are danger zones, how much area is inundated? How much rainfall will occur? These questions can be drawn on the map representing the actual environmental conditions.

3) Knowing about processes of reasoning. Knowing about the reasoning process that leads to problem-solving through a spatial perspective. It uses various cognitive skills and knowledge. For example, how to determine a good evacuation route when a tsunami strikes? Where is the safe meeting place when an earthquake strikes? These questions require good reasoning abilities and must be taught to students.

4. Conclusion

Some conclusions in this study are: (1) there was an increase in students' knowledge about disasters. This is seen from the classical completeness in every action. In the first action, learning was not effective (52%). This was because students were not accustomed to using spatial thinking in learning. On the second action, it showed an increase in classical completeness (92%). This was affected by stimulating learning and students' increase in motivation to learn disaster material. Besides, the learning that was carried out also utilized geospatial technology such as GIS and Google Earth. Geospatial technology could help students to use spatial thinking, for example in understanding spatial patterns and linkages. (2) Through spatial thinking, students can more easily understand the concept of disaster. Spatial thinking includes three key components, namely: (a) spatial concepts as space and direction around them, such as points, region, distances that are important objects and need to be known when disaster strikes; (b) representation tools to be understood by students, such as maps of both two dimensions and three dimensions in an area used to understand abstract representations on maps with the real world; (c) the process of reasoning that leads to problem-solving through a spatial perspective using various cognitive skills. Thus, this study illustrates the importance of the application of spatial thinking in disaster education. Therefore, schools should facilitate teachers to implement disaster education based on spatial thinking in preparing young people to face disasters.

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