Students’ logical mathematical intelligence in completing mathematical problems with natural disaster context

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Abstract. Disaster awareness in the community is necessary to be improved continuously, especially for regions in Indonesia that are prone to natural disasters. One way to do is to integrate disaster problems in mathematics learning. Teachers need to train students to solve mathematical problems in the context of disaster. Through this problem, it is expected that students' logical mathematical intelligence will increase. This research is a preliminary study to determine the logical mathematical intelligence of students in solving mathematical problems in the context of disaster. The participants in this study were all 23 junior high school students in class VII at SMPN 1 Peukan Bada, Aceh Besar. These students were domiciled in the 2004 tsunami-affected areas registered and members of the Disaster Preparedness Schools (SSB). The data in this study were collected through tests and interviews which were analyzed descriptively. Based on the indicators of logical mathematical intelligence, it was concluded that students' logical mathematical abilities in solving mathematical problems in the context of disaster were in the low category, even though students in these schools already had knowledge of disaster through disaster simulation activities. Thus the mathematical learning design is needed to improve students' logical mathematical intelligence in solving mathematical problems in the context of disaster.

Keywords: logic-mathematic intelligence; contextual learning; problem solving, disaster preparedness

1. Introduction
Logical-mathematical intelligence is defined as the ability to make reason logically, use numbers effectively, associate patterns, identify logical relationships, compare and test hypotheses [1]. Among multiple intelligences theory [2], Logical-mathematical intelligence also plays an important part in the learning process. Students’ ability to use reasoning and logic is the basic asset in understanding mathematics while good reasoning is predicted as one of the factors that influence students' academic success in the future [3]. One way of assessing this intelligence can be obtained through ideas and representations of knowledge possessed by someone manifested through symbols such as images, language and mathematics. These symbols and images system are used in various scientific disciplines in life and plays an important role in solving certain tasks or problems [4]. The fact shows that the students’ level of logical mathematical intelligence is still below the average and becomes a major problem in learning mathematics. In other words, the weak ability of students to think and use logics reasoning is the main obstacle to achieve effective mathematics learning goals.
Mathematical learning is very important in helping students to prepare themselves in the future in social life [1][2]. Learning becomes meaningful when students are actively able to associate and apply learning material in accordance with real life that is encountered every day, namely by using contexts that are close to their daily lives. Context is generally interpreted as a situation that has something to do with an event. Context gives meaning to content which results in a link between the meaningfulness of subject matter and everyday experience. Learning is said to be meaningful when the lesson can be applied and applied in real life. Quality meaning is a contextual meaning that links teaching materials to personal and social environments [3] and a context gives meaning to content which results in a link between the meaningfulness of subject matter and everyday experience[4]. Learning by using contexts provides more opportunities for students to demonstrate their abilities [5], so that they can explore and construct thinking in accordance with the conditions in their living environment. This is also in accordance with Vygotsky's learning theory which emphasizes between internal and external aspects of learning, namely that the learning process is influenced by the environment and socio-cultural factors in society which are the main determinants for constructing knowledge [6][7]. As a consequence, the meaningful learning will be achieved when students are able to construct their thinking using contexts.

People living in disaster-prone areas are normally familiar with mitigation, rescue, and evacuation as well as recovery processes as a direct consequence of geographical, geological, environmental and climatic relationship. Aceh for example, is one of the provinces in Indonesia that has a high risk of the threat of natural disasters. Almost every year, disasters such as floods, landslides, droughts occur in Aceh. During 2018 there were 34 natural disaster events in Aceh and floods were the most frequent events [8]. Aceh has also had a long history of previous major disasters such as the 2004 earthquake and tsunami, and the 2016 Pidie Jaya earthquake which caused very significant loss of life and economic losses. These disaster events can actually be used as the unique problem solving materials in the learning process through four stages: understanding problems, planning solutions, implementing plans, and checking answers [9]. Hypothetically, an initiative to integrate the disaster contexts events into mathematics learning would be a worthwhile research.

When referring to the important role of education described earlier, education in Aceh and Indonesia should make the disaster risk reduction program a top priority and integrate it into the curriculum and field of study in sharing education levels. Historically, Sekolah Siaga Bencana (SSB) or Disaster Preparedness School was probably the first systematic program which was established in Aceh province in 2009 that integrated disaster education in the school curriculum as a school preparedness effort against disasters. This SSB is applied to one elementary school (SD), one junior high school (SMP), and one high school (SMA) in the city of Banda Aceh, which aims to provide disaster education and knowledge to students from an early age. The theme of the disaster was integrated in the subjects of Religion, Indonesian Language, Social Sciences, Natural Sciences, and Local Content. In 2011, the Tsunami and Disaster and Mitigation Research Center (TDMRC) of Syiah Kuala University began to expand this SSB model into 28 schools in different places in Aceh that applied learning separately from subjects and conducted outside school hours [10]. The presence of the (SSB) formed by the Aceh government showed that education can also participate in disaster risk reduction, however, the implementation of the SSB has not been optimal yet and has not been integrated into mathematics subjects.

Increased attention to disasters is caused by awareness of the dangers of disasters which are part of human life which often cannot be predicted when, where, and how much impact [11]. Education has proven to be one of the best media to make people more aware of disaster risks. The best way to disseminate Disaster Risk Reduction (DRR) awareness programs is to integrate these initiatives into educational programs in schools. Some aspects such as health, safety, danger and threats have been implemented in schools both in Indonesia and in various countries. Various forms of teaching innovation and learning approaches (see Figure 1) through teaching books, games, learning, songs and so on can be used as media to introduce students to disaster risk [12]. The aim is to increase students' knowledge and understanding of risk, teach preparedness, and teach how to act during
disasters [13]. Learning from the experiences of countries most often affected by disasters such as Japan, makes this country more aware and prepare an education system called "educational resilience" or education that has resilience (resilience, preparedness, resilience) to disaster risk. This includes student resilience, teacher resilience and school resilience, which is a transition from individual resilience to system resilience [14].

![Teaching instruments to introduce DRR](image)

**Figure 1.** Teaching instruments to introduce DRR [12]

The ability of students to think and act quickly when a disaster strikes, understand evacuation routes and think about how to save themselves when a disaster occurs related to the logical-mathematical intelligence they have. The better reasoning ability possessed by students will make it easier for teachers to carry out well-designed learning processes [15], one of which is students are able to solve mathematical problems in the context of disaster. Logical-mathematical intelligence is expected to improve for the better through meaningful learning with a contextual approach [3] that links the context of disaster in real life. The increase in logical-mathematical intelligence is also expected to help the impact of Disaster Risk Reduction (DRR). Therefore, the formulation of the problem in this study is “How do students' logical-mathematical intelligence solve the mathematical problem solving in the context of disaster?”.

**2. Method**

This study is a descriptive study with a qualitative approach. This is based on the formulation of a problem that requires data on students' logical intelligence through tests and interviews. In this case the test was used only to identify students' abilities so that mapping and grouping can be carried out based on the logical-mathematical intelligence possessed. Data supporting information obtained from interviews discussing the processes and results achieved and it was measured based on indicators on students’ logical-mathematical intelligence. The qualitative approach [16] is used because this research emphasizes investigative efforts to examine students' logical-mathematical intelligence naturally through a learning approach in the context of disaster.

This study was conducted in one of the junior high schools (SMP) in Aceh Besar district in April 2019. The selection of this school was based on the initial observations of schools included in the category of the SSB. The subjects in this study were 23 students in class VII of SMP. The selection of this subject was done due to suitability with chapter being taught in the class, which was “Comparison”. A test was conducted to identify and classify students based on logical-mathematical intelligence to solve mathematical problems. Based on these results, 6 students were chosen as representatives of each assessment criterion and were interviewed to obtain information on the impression of the problem previously given.
Data collection was taken through interviews to figure out more about students' logical-mathematical intelligence. The data was previously obtained by giving individual test questions after taking part in learning with one of the mathematical material that was integrated into the context of disaster. In this study, the main instrument was the researcher himself. This is because researchers conducted in-depth interviews with subjects to obtain information needed in data collection. Interview on the answered sheets and results aims to observe more about students’ logical-mathematical intelligence after learning. The interview guide was in the form of outlines of the problems to be asked which were made based on the indicators of students' logical-mathematical intelligence. Interviews conducted are semi-structured, in accordance with the communication style of students with the aim of finding problems more openly. In this case the researcher asks questions related to the purpose of adding information and clarifying students' answers to the test of logical-mathematical intelligence.

Data analysis was carried out by describing the results of student interviews based on low, medium, and high categories by analyzing the results of tests of students' mathematical problem solving based on logical intelligence. This study followed qualitative data analysis model of Miles and Huberman [17] which consists of three stages, namely data reduction, data display, and verification.

The validity of the data obtained was examined by using data credibility test with triangulation. There were three types of triangulation, namely triangulation of sources, data collection techniques and time. In this case the researcher used technical triangulation and time. The procedure of research carried out in this study included three stages, namely the preparation stage, the implementation phase, and the data analysis stage. At the preparation stage, the initial step taken by researchers was by conducting research observations and permits.

At the implementation stage, research was carried out using validated instruments. Test the problem solving problem with the disaster context to identify students' logical intelligence, then students were grouped by low, medium and high categories. The next step was to select 6 students who were included in the criteria to be interviewed thoroughly related to the learning concept according to the research objectives. After carrying out all the research processes, the next step was to analyze the data by describing the results of interviews and tests to group students. The processing and analysis of data that has been carried out, were then parsed and discussed further in the discussion section.

3. Results and Discussion

This study aims to identify students' logical mathematical intelligence by solving mathematical problems in the context of disaster. The ability of students to use their imagination and think logically in making choices or decision in the event of a disaster such as choosing the path of evacuation routes that are rightly expected which hopefully can help to reduce the impact of disaster risks. The topic of “Comparison”, which consists of one story problem with two different questions (See Figure 2). The first question was equipped with indicators of mathematical reasoning to understand on how students to use their imagination and make guesses about a problem. Whereas in the second question with indicators of mathematical problem solving abilities to derive observation on how students carry out the right counting operations and draw final conclusions on the problems given so students are able to make the right choices in saving themselves when a disaster event strikes. Examples of questions given are as follows:

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Figure 2. Example of a disaster context-mathematical problem

Textually the question is in accordance with the situation and conditions in the neighborhood where the students are lived. The surrounding elements such as school location, coasts, hills, vertical evacuation shelters as well as the direction (north, west, left, right) were described as similar as the reality. Based on the logic possessed and the comparison of the distance that the subject in the sample problem has known, the student must make a decision where to run to escape from the tsunami. The example of the student answer sheet is illustrated in Figure 3.

Figure 3. Example of Student Answer Sheet

The assessment steps are set as follows: (1) Seeing the completeness of the components, in the form of six components that must exist, namely the direction, four positions of objects (people, sea, hill and disaster evacuation building), and the distance between the the person standing with the hill and the evacuation building. If students answer all the components without seeing the right or wrong of their answers, then a score of 6 will be given; (2) The sense of direction, which is the ability of the students in mentioning the direction of the wind (north, east and west) perfectly according to the position of the object will be given a score of 2, whereas for students who can answer but incorrectly will be given a score of 1 and a score of 0 will be given to students who do not answer; (3) Position of objects, which is the ability to answer exactly the location of the sea, hills and disaster evacuation buildings. For students who can answer 3 objects completely, they will be given a score of 3, if they can answer only 2 objects, they will be given a score of 2; (4) distance, i.e. the distance between the person standing with a hill (500 m) and the distance between the person standing with the disaster evacuation building (900 m). Then the four steps are summed for each value obtained and specified (see table 1).
The results of logical-mathematical reasoning test are then distributed into three categories: low level with the intervals of 0-33%, then 34-66% for the medium category, and 67-100% for the high category. The results of the research on logical-mathematical intelligence of students for the first question showed that there were 13 students with a low reasoning category in their logical-mathematical intelligence, 8 students in the moderate category and 2 students with a high category. Thus, it can be seen that the majority (57 percent) of logical-mathematical intelligence of students in the reasoning indicators fall into the low category (see table 2).

The findings described in table 1 and table 2 show that the students’ reasoning abilities and mathematical problem solving are still classified as insufficient, in other words mathematical logical
intelligence of students in solving mathematical problems in the context of disaster falls into the low category. Whereas in mathematics learning, mathematical logical intelligence has more important roles than other types of intelligence because students need special skills in solving problems given to them[18]. Students with strong logical intelligence, more successful in classifying various problems given, are able to build a logical relationship of each problem, can calculate quickly and precisely and can build linking the subject matter of each real event [19]. Students who have good mathematical logical intelligence are able to understand the causes and effects of a problem in mathematics learning, and can use reasoning and logic to solve mathematical problems well [20]. Therefore students who have a good level of mathematical logical intelligence, indirectly can be seen from how these students can solve mathematical problems.

The assessment on the second question is based on students' ability to carry out counting operations by using the right instincts. This question is to identify the students ability to think logically and critically when reading the questions. The goal is to solve and provide right answer in counting operations (Comparison) in accordance with mathematical rules and is to draw final conclusions to problem solving in the context disaster-mathematical problem. If students only use their instincts in answering the question, they will be given a score of 1, whereas for students who use instincts as well as perform count operations but it is not appropriate to be given a score of 1, and for students who use instincts and perform precise and perfect counting operations, they will be given a score of 2.

The results showed that as many as 65% of students solved problems by using their instincts, while 35% are able to apply counting operations with incorrect answers. There was no student could solve this problem precisely as desired. Based on table 3, it can be concluded that the logical-mathematical intelligence of students in performing the counting operations in the Comparison topic with the context of natural disaster falls into the low category.

| Category     | Indicator                        | Number of Student | Percent |
|--------------|----------------------------------|-------------------|---------|
| Low          | Student is able to use the instinct | 15                | 65      |
| Moderate     | Student is able to use the instinct but answer incorrectly | 8                | 35      |
| High         | Student is able to use the instinct and answer correctly | 0                | 0       |
| **Total**    |                                  | 23                | 100     |

Source: Author calculation (2019)

To get more thorough information to be supporting reasons for the results of this study, an in-depth interview was conducted with the object of research by choosing 6 students as the representative 23 students. These consisted of 2 students from each category of logical-mathematical intelligence. The results of the interview indicate that solving disaster context-mathematical problems are difficult to solve, for several reasons: (1) it required a deep understanding when reading the content and context of the story in the question; (2) Long, comprehensive, multi-aspects in the single question were not desired; (3) it is the first time for students found a story problem in the context of disaster; (4) Even though they have received evacuation simulations and disaster education from external institutions, there has not been any disaster integration into mathematics learning material, therefore, students find it difficult to solve it.

From the results of interviews with several participants, it was shown that students felt difficulty in solving the questions given because they were too long so that it was difficult to be understood logically. This indicates that the mathematics literacy level of students is low, which indirectly also shows the level of mathematical logical intelligence of students is also low. In fact, students will need
a lot of mathematical and other skills in solving mathematical problems. But in reality students have not yet obtained the basic skills they need, as a result they face many difficulties in solving the problems given [21]. Therefore, students need to be accustomed to solving contextual mathematical problems so that students' abilities in solving mathematical problems also increase. One way is to improve teaching and learning to be more effective and meaningful through the real experiences that students encounter in their daily lives, namely through a contextual learning approach.

Learning by integrating the existing context from the surrounding environment can motivate students to connect the subject matter with the real world that is experienced and can be applied to their lives. In addition, through contextual learning the teacher can also train students to prepare themselves in facing more complex life problems in the future [22]. So that mathematics learning in the context of disaster can be used as a solution to improve students' logical mathematical intelligence in solving mathematical problems and can provide benefits in helping the impact of Disaster Risk Reduction (DRR) especially for people who live and live in disaster-prone areas.

From the viewpoint of disaster education and mathematic learning-teaching, such as disaster evacuation routes and symbols are a big gap related to mitigation and risk reduction during disasters. The content of mathematical questions is actually in accordance with what they have experienced and learned, which means "context" in mathematics learning is very appropriate as a solution to improve students' logical-mathematical intelligence in solving mathematical problems. Mathematical learning with a contextual approach is considered appropriate for students who live in disaster-prone areas where they can associate learning material with real life that is met on a daily basis and will eventually be able to apply to reduce their risks. Although, better logical mathematical intelligence through completing mathematical problem solving in the context of disaster can provide benefits in helping the impact of Disaster Risk Reduction (DRR), further research on the delivery and integration into mathematics are strongly encouraged in the future.

4. Conclusion
The ability of students to use imagination and think logically in making decision in the event of a disaster such as choosing the evacuation routes that are rightly expected can help reduce the impact of disaster risk. Based on the indicators of students logical-mathematical intelligence, it was concluded that only small number of students from the total samples were capable to meet the reasoning test. Additionally, the students' logical mathematical abilities in solving disaster related mathematical problems were in the low category. This result indicates the needs of improvement in the education, including mathematics curriculum, even though the students had already knowledge about disasters through disaster simulations in their school held by disaster management agencies. Thus, improved design in mathematics learning is needed by integrating context into the learning curriculum. In this case, the objective is to improve students' logical mathematical intelligence in solving mathematical problems in the context of disaster.

This study suggests that further research is needed regarding the lack of student literature studies in reading, understanding and training themselves to get used to solving mathematical problems based on contextual environment such as natural disaster. In addition, it is also possible to conduct further research related to Cognitive Load Theory (CLT) which influences students' performance in solving mathematical problems, so that students can make decisions quickly to use instincts as well as perform accurate counting operations.

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