Integrating STEM (Science, Technology, Engineering, Mathematics) and Disaster (STEM-D) Education for Building Students' Disaster Literacy

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Abstract—This paper discusses about innovation strategy to build students' disaster literacy through integrating STEM (Science, Technology, Engineering, Mathematics) and Disaster (STEM-D) Education. Indonesia is risk of many disasters e.g. earthquake, tsunami, volcanic eruption, and flood. Through STEM-D students are taught the relation between STEM concepts and disasters occur in Indonesia. The six steps of STEM-D are observing, identify and planning, discussion, question and answer, elaboration, and reflective.

Index Terms—students' disaster literacy, STEM, disaster, STEM-D.

I. INTRODUCTION

Indonesia has to cope with the risk of volcanic eruption, earthquake, flood and tsunami because Indonesia is located on the Pacific Ring of Fire (an area with a lot of tectonic activities). In Java Island itself, 120 million people live in the shadow of more than 30 volcanoes [1]. One of the world's most active volcanoes, Indonesia's Mount Merapi is the bringer of life and death for a wide swath of the island of Java [2]. On several occasions during the last 16 years, Indonesia has made global headlines due to devastating natural disasters that resulted in the deaths of human and animal lives, having a destructive effect on the land area (including infrastructure and economic costs) [3].

Based on data of disaster in Indonesia showed that disaster is the main threat. From 1.525 disasters, caused 566 people died, 2.66 million people are evacuated, more than 51 thousands of house damaged, and hundreds of public building damaged [3]. Besides that, 99 percents of disaster during 2014 is hydrometeorology disaster like tornado, floods and landslide, disaster event data dated on 31 December 2014 shows that 1567 disaster during a year, the average of disaster event in Indonesia is 131 events in a month or 4 events in a day [4]. This number is sizeable for disaster, thus there must be efforts to reduce and solve the disaster risk in Indonesia.

Disaster literacy is defined here as an individual's ability to read, understand, and use information to decide a good decisions and follow instructions in the context of mitigating, preparing, responding, and recovering from a Indonesia. 383 disaster [5]. In of 483 districts/municipalities are disaster prone [6]. Most people in district that is vulnerable disaster do not have knowledge about disaster mitigation. Disaster literacy is very important to reduce the disaster risk, especially in Indonesia because most of natural hazards occur in Indonesia such as tsunami, tornado, floods, landslide, and volcanic eruption.

Many efforts to reduce the disaster risk in Indonesia have been done by many institutions (government institutions, UN agencies, NGOs, donor agencies, and private actors). UNESCO as UN agency that contribute to peace and security by promoting international collaboration through education, science, and culture has developed two supplementary learning materials on natural disaster preparedness for junior and senior high school students. This way is to improve fundamental knowledge of student on what disaster is and how to reduce the disaster risk because there is no scientific reference and knowledge towards this in current school curricula [7]. So, there must be new learning strategy that connects between disaster and student scientific knowledge that can improve student's skill and knowledge about disaster.

Education in Indonesia should be taught by suitable approach for introducing disaster mitigation well for student as early warning system because based on data, disaster risk cannot be avoided. STEM (Science, Technology, Engineering, Mathematics) education approach is a good way. Teaching STEM in the primary and secondary education can help students become interested in STEM careers and build a nation's STEMeducated workforce [8]. STEM has two basic goals, first is to prepare students to enter area careers in science, engineering, technology, and mathematics, and second is to improve student basic knowledge of science, technology, engineering, and mathematics [9]. Integrating STEM and Disaster (STEM-D) is strategy that can help student to understand about science knowledge itself and

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the relation with disaster. Thus, by implementing STEM-D education the instruction in the class room or laboratory can be interesting and contextual.

II. LITERATURE REVIEW

A. Disaster Mitigation and Education

Disaster mitigation can be defined as measures taken in advance to reduce the impact of a disaster and it includes structural measures such as safer building construction and non-structural measures such as education, training, and technology transfer [10]. Disaster mitigation is the way that eliminate or reduce the impacts and risks of hazards through proactive measure taken before an emergency or disaster occurs [11]. In the Indonesian Disaster Management Law 2007, disaster mitigation is classified to be the measure before disaster which includes the activities of (a) land use management, (b) development planning, infrastructure development, building code, and (c) education, training and drill [12]. Despite the fact that mitigation education and risk awareness can reduce losses and fatalities [13]

B. STEM Education

STEM education can be defined as an approach to teaching and learning everywhere between two or more in components STEM or between a component STEM which other disciplines [14]. STEM education approach in this article refers to the definition is given by [14], which integrate mitigation thinking in teaching and learning of science education in schools. In general, integration of STEM education, from primary school to university. This may be due to aspects of the implementation of such STEM intelligence, creativity, and design capabilities are not dependent on age [15]-[16].

STEM integration initiatives in the school curriculum is one way to enhance or encourage students interested and engaged in STEM fields. At this time, students' interest in STEM fields in various countries like USA, UK, Malaysia, and Indonesia also decreased, while the national and industry requirements for background STEM fields is higher [17].

III. DISCUSSION

STEM education is used to improve student learning. As a growing trend in the academic world, STEM education is used to address real-world situations through a design-based problem-solving process [18]. STEM advocates argue approaching education so that students can recognize their education as applicable and essential [19].

Disaster that often occurs in Indonesia make the science learning implement about disaster education. It means that subjects (especially science learning) should be taught related to disaster education. Thus, through STEM-D the student is taught about disaster literacy early. An integrated approach to STEM education makes

STEM content areas as one subject [19]-[21] which integrates STEM and disaster education. Integration is distinct from embedding in that it evaluates and assesses specified standards or objectives from each curriculum area that has been incorporated within the lesson [22].

Below are the six-steps of STEM-D in learning to make the instruction work well:

Observing: The students observe the disaster phenomena around them in some groups. The phenomena can be observed through videos or directly on what occurs around them. Video is option if there is not the phenomena that can be shown around students' circumstance. Video should catalyze theory, knowledge and understanding [23]. In this step, the students observe the STEM concepts related to disaster, how science, technology, engineering, and mathematics are explained.

Identifying, Planning and Act: In this step students identify the problems from the phenomena that they have observed, make hypothesis and develop strategies to solve the problems. The students have to make and prepare planning research work. Research work has to be contextual with condition around them. In this step students' science process skills begin to improve. Where the science process skills are embedded related to scientific literacy [24]. Scientific literacy can develop basic education [25]. The activities that student can do are experiment, internet searching, making project

Discussion: The students make discussion about what they have made about their planning research work. Each group presents their work and the discussion hopefully works well. The active learning has to have question, pro and con grid, brainstorming, formative quizzes, thinkpair-sharing, short writes, problem solving, modeling analytical skills, debates, and role playing [26]. On discussion step the students are expected to achieve the correct direction of scientific process [27]. Science process skills refer to learners' process of understanding new meaning from experience and information [28].

Question and Answer: In this step after making a discussion another group should make a question to the group who has delivered presentation. The questions or suggestion should be constructive to make improving in critical thinking. While answering the questions that their friends give it also related to constructivism. From a constructivist paradigm, the students' knowledge originate based on their activity performed on object [25].

Elaboration: The students present their result in variously. Each group makes a collaboration to each other. So that, the ideas about solution in disaster based on STEM concepts can be shared to each other. In this step the students can go deep into material that has been discussed, make deal with cooperation and collaboration, and together to make conclusion based on their opinion before the teacher confirm.

Reflection: In this step the STEM concept is cleared up related to disaster phenomena. The student's basic knowledge (STEM concept) is confirmed so that there is no misconception. So, the disasters occur in Indonesia are analyzed as those occur because of natural phenomena that can be explained by STEM concept. The activities that student can do are experiment, internet searching, making project or conducting discussion in some groups and share the knowledge. While the learning activities are in progress the students are observed about them skills and attitudes. So that, the learning activities of STEM-D result can be assessed.

On Fig. 1 below is conceptual framework where STEM and disaster are integrated to make innovation strategy in learning. The objectives of student is improving STEM concept and disaster literacy.



Figure 1. Conceptual framework of STEM-D.

IV. CONCLUSION

Through STEM-D education, students' disaster literacy is intended to make them ready facing Indonesia natural phenomena related to disaster. Besides that, by analyzing the phenomena and making solution, students are also trained to explore and improve STEM concept that will be useful for the future. Whereas, many future needs cannot be separated from science, technology, engineering, and also mathematics.

For further development STEM-D education can be developed as school based community. So, disaster mitigation is taught as community not as instruction that some people outside school can join to share together about disasters occur in Indonesia.

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