STEM in Disaster Learning Media: A Literature Review

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A I Agusty*, F A Alifteria, and M Anggaryani
Physics Education, Universitas Negeri Surabaya, Indonesia

*Email: alifia0708@gmail.com

Abstract. What is a natural disaster? How much do we know about it? Modern technology undoubtedly helped people learn about natural phenomena that sometimes can be misdirected into disaster. Natural disasters can cause quite an enormous impact, such as property damage and the number of injured or dead victims. Disaster education that applied science, technology, engineering, and mathematics could be a potential strategy to prepare the local community in managing the risk of natural disasters. This study is part of literature research on the integration of STEM in disaster education focused on disaster learning media to increase students' awareness of disaster prevention, impacts, and mitigation. This study aims to identify national and international journals related to STEM, disasters, and learning media; and evaluate the effectiveness of implementing STEM integrated learning media. In 2011-2021 there are 305 publications and 15 articles reviewed in this study. The results indicate that STEM-based disaster learning media can develop students' ability to solve problems related to disaster mitigation and disaster knowledge. The development of learning media to teach disaster education need to be reviewed and adapted to the geographical conditions of Indonesia, several topics about disaster as recommendation for learning is disaster that often afflict Indonesia.

1. Introduction

In the first-quarter of 2021, Indonesia has been threatened by 1,205 natural disasters dominated by hydro meteorological disaster with 501 events of floods, 339 of hurricane, and 233 of landslides [1]. The numbers of disasters in Indonesia can be caused by the geographical location which on the Pacific Ring of Fire and between three large tectonic plates: Indo-Australia plates, Eurasia plates, and Pacific plates [2,3]. These conditions can threaten to occur earthquakes, tsunamis, and landslide. Due to these geographical conditions, it has a big potential for disaster to occur with various characteristic, so that the management has their own handling for every disaster [4]. Natural events that causes disaster is difficult to predict even the movement of plates and through geological calculations can be ascertained, but it's difficult to avoid the impact of disasters. Improper disaster mitigation and management can cause the high number of deaths, losing property, damaging the environment, and affect the psychological condition of local community. The disasters that occur by July 2021 in Indonesia damaging 767 units of property, and 4 death of victims [5]. Those impact of disaster can be reducing by applying the technologies to announce the early-warning to their local community in the disaster prone-area, but it costs a lot. The effective and simpler way to reduce the impact of disaster and also increasing risk awareness of local community can be done through school by developing disaster knowledge integrated with several subjects to students [3,6].

Science, Technology, Engineering, and Mathematics (STEM) in Indonesia has supporting students facing the Fourth Industrial Revolution (Industry 4.0) in these years. The rapid development on the issue of STEM education provides students to increase their abilities, skills, knowledge of fact, procedures,

concept, metacognitive skill [2], and science process skills [7] to be ready as future human resources in the STEM fields. The integration of STEM education in teaching and learning should be applied to all levels of education [8]. STEM education also impacted into student's motivation and directly involving students into the manufacturing process [9,10]. The implementation of STEM is related to the teachers as an important role to integrate STEM into their class. Teacher can integrate STEM as a learning strategy, learning approach, the method of learning, assessment, textbooks, teaching materials, and learning media [11,12]. In these pandemic COVID-19 era, textbooks are not an effective way to deliver the learning material for students because of School from Home (SFH) regulation, students need an interactive way to learn some subject. Teacher that integrate STEM usually gives an explanation through listening material, e-book, interactive learning media, or a video [7].

Natural disaster in Indonesia need to be manage seriously and intensively especially in disaster-prone areas, the alternative way is through education sector. By introducing students to disaster education including disaster mitigation, disaster prevention, and disaster preparedness, it can enhance students' awareness of disaster in early stage [13] and they can act to saving the nature. It also has the same important role as giving the early warning to local communities before the disaster. Disaster knowledge or education can be taught in schools, it also affected students understanding in dealing with disaster [14] using an interactive learning media. The communities' disaster preparedness knowledge is still lack even they lives in those area for a long time [13]. The high risk they will face when a disaster occurs, both physical and environmental losses need to be increased through a disaster education. Disaster can be taught by integrating science learning process that have strong relation to disaster such as physics with an appropriate learning model [14]. Using learning media can simulate disaster in greater way such as given information process with a physics-analogy warning [14], explain the disaster management policy, visualize the disaster prone-area in Indonesia. Developing disaster learning media itself gives teacher a challenge to explore their creativity to be able to build a meaningful understanding of natural disaster [15].

The interpretation of learning media is to deliver learning meaning [16,17]. Learning media is designed by a teacher to adjust the material with their students' imagination. The advantage using learning media is to carry out learning process effectively and more efficient by considering the learning goals [18]. By implementing audio-visual feature to learning media can boost students' attention to the maximum level in learning process. Integrating STEM into learning media in disaster education related topic should be the innovative way to teach students disaster awareness so they will perceive that learning in attractive, fun, and more profound [17]. By simulating the process of disaster using visualization, audio, and video can engage students' imagination towards disaster in various aspects. Therefore, this research aims to identify national and international journal in STEM, disaster, learning media topic using literature review method and evaluate the effectiveness of implementing STEM integrated learning media.

2. Method

This research method applied in this study is literature review for reducing a potential bias that possibly occurred when it comes to scientific procedures in diverse research approach. This literature review uses secondary data from several journals national and international, which relate to Disaster, learning media and STEM. The searching process focused on the literature written in English and the period of 2011-2021. Researchers using "Disaster", and "Learning Media" and "STEM" keywords in database. There are 305 articles that match with the keywords found on *Google Scholar*, the researcher chooses 15 articles that are very relevant to STEM-based disaster learning media and physics topics. The selected articles are articles that focus on discussing STEM-based disaster learning media at the elementary school to high school level especially in physics topic so the discussion only focus in the implementation of STEM in Indonesia disaster learning system.

After collecting some journals, the data were analysed using descriptive qualitative analysis through literature review. The articles in this literature review were analysed, extracted and synthesized and then summarized the results related to "Disaster", "Learning media", and "STEM". The process of analysing

the articles resulted in the essence of the research, namely: the name of the researcher, the year of publication, the title of the study, the results and conclusions of the study. The extracted digest is then entered into a table so that the extraction results are easy to read [19].

Figure 1. Step of literature review research

The author discusses three steps to conduct literature review research which exemplified by several activities in qualitative data analysis as follows:

1. Identification. Identify data obtained from journal reviews, to obtain the required information.
2. Examination. From the data that has been obtained then summarized, write down the main points and focus on the discussion that will be discussed so that the objectives and results of data analysis have a clear picture.
3. Interpretation. The data that has been analyzed is presented an explanation in the form of a description and drawn conclusions from the data obtained so as to produce answers to the formulation of the problem.

3. Results and Discussion

3.1. Studies related to STEM, Disaster, Learning Media

The integration of STEM in disaster learning media has been a new strategy for Indonesia education sector to enhance students' skill in STEM and also increasing students' awareness of disaster. This disaster studies topic and the use of learning media as a tool to deliver disaster education from 2011-2021 there are 305 articles from national and international journal that match with the keyword and 15 article meets the criteria of these study including the author(s), year, and learning media type as shown in Table 1. Publication in the 2019-2021 are mostly concern in the case-study of the studied articles in Indonesia disaster, and the technology used in learning media to deliver disaster learning is still accordance with current research trends.

Table 1. Studies related to STEM, disaster, and learning media

No	Article Title, Author, & Year	Learning Media Type	Substance
1	Development of Digital Teaching Materials on Earthquake Themes to Improve STEM Literacy. A Hikmawati, D Puspitasari, D Ardianto, and S Kurniasih. 2020 [7]	Digital Learning	The development of digital teaching materials on earthquake using ADDIE model was collected using validation sheet, valid question about STEM literacy, and questionnaires. The result that digital teaching materials designed can improve STEM literacy in the medium category
2	STEM project-based learning on student's STEM literacy: the case of teaching earth layer and disaster. Kartini, F.S., Widodo, A., & Winarno, N. 2021 [2]	-	In 2019, Indonesia not only threatened by COVID-19 but also natural disaster. STEM-Project based learning are designed to teach students about

			earth layer and disaster topic. It is recommended to enhance students STEM Literacy
3	STEM Education Implementation in Indonesia: A Scoping Review. Farwati, R., Metafisika, K., Sri I., Sitinjak, D.S., Salikha, D. F., & Salfarina, S. 2021 [11]	-	There are 597 articles based on research conducted in 2015-2020 about STEM education in Indonesia. The implementation of STEM education has support teacher in many ways and it can be a trigger as a new strategy in education sector
4	MEMS and IoT applications in ISLE-based STEM physics learning media for mechanic's topic with LabVIEW integration. Irwandi, I., Sari, I. M., Oktavia, R., & Syukri, M. 2020 [20]	Application	In the 21st century, technology such as sensor and IoT (Internet of Things) have not been optimally used as a media for physics learning. From the research, students' knowledge about mechanics was develop while conducted to the experiments. The learning process was very fun using STEM approach.
5	Development of Module Disaster Mitigation Based on STEM for Secondary School. Septaria, K., Dewanti, B. A., Afidah, M. I. E. 2020 [21]	Module	The validation result of disaster mitigation module is 95.75% in average point which categorized as very valid. The module itself is interesting and can improve student learning outcomes towards COVID-19 disaster.
6	Preparedness of Preservice Elementary Teachers' Nature of Science (NoS) Understanding for Better STEM Learning. Subuh, A. 2019 [22]	-	Main purpose of learning science is to enhance students' literacy. The better understanding of students literacy can be an easier way to solving a problem mainly in NOS Understanding using STEM learning
7	The movement of STEM education in Indonesia: Science teachers' perspectives. Nugroho, O.F., Permanasari, A. & Firman, H. 2019) [10]	-	Teachers are an important role to integrate STEM into their learning process. This research was examining teacher perception on STEM education. The result is teacher have a good understanding to STEM education
8	KOASE: Disaster Mitigation Learning Media in Elementary School. Noviana, E. Kurniaman, O., Affendi N. 2020 [23]	Comic	Developing KOASE comic to teach elementary students was appropriate to teach disaster mitigation as a medium for learning. It has a very good

			category according to teacher and students responds.
9	Multimedia in Disaster Risk Reduction. Sejati, P. M., Budiningsih, C. A. 2019 [16]	Attractive learning media	Multimedia is a new medium to create interactive learning process to the students. According to the research, it is necessary to use attractive learning media to improve students' comprehension. By applying attractive learning media, students also can improve their disaster risk knowledge.
10	STEM-based learning analysis to improve students' problem solving abilities in science subject: A literature review. Astuti, N. H., Rusilowati, A., & Subali, B. 2021 [24]	-	Physics is a subject that requires students' problem solving abilities. From this literature review study, combining STEM into physics education can improve students' problem solving abilities.
11	Google Earth Pro as a Learning Media for Mitigation Adaptation of Landslide Disaster. Rany, T. D., Kuswanto, H., Abdillah, A. J. 2020 [25]	Google Earth-Pro	Determining the learning outcomes using Google Earth Pro as media-assisted inquiry model in landslide disaster mitigation. The Google Earth Pro-based media has a higher point to improving students learning outcomes than using Power point media.
12	The Encouragement of 21st Century Skills Through the Integration of STEM Activities in Basic Education. CA. T. 2019 [26]	-	Digital technology is some issue that challenge teacher having the 4C skills. In the 21st century the young generation must sharpen their minds to support the education for facing the digital technology to support learning process in STEM activity.
13	STEM at home: provide scientific activities for students during the Covid-19 pandemic. Zulirfan, Z., Yennita, Y., & Rahmad, M. 2020 [27]	Science Kit Project	Because of COVID-19 pandemic, students' scientific activities were decrease because of school from home regulation. This research was developing module and kit of STEM Project so the students can have scientific literacy in their own home.
14	Developing of a learning media for smartphones for Disaster Mitigation Education Wahyuningtyas, N., Ruja, I. N., Yahya, M. H. 2020 [28]	smartphone-based	Community need to learn about disaster mitigation as an important prevention towards disaster. Using mobile encyclopedia in a smartphone

			application for volcanic eruption disaster education. This media able to give others learning media option for teacher.
15	STEM Education in Indonesia: Science Teachers' and Students' Perspectives. Permanasari, A., Rubini, B., & Nugroho, O. F. 2021 [29]	-	Using survey approach to analyze teacher and students' perceptions towards STEM. Teacher shows positive feedback towards STEM education, but they have not yet applying STEM Education to their learning process. It causes student understanding toward STEM in weak level.

Based on the literature using STEM, learning media, and disaster theme. the most commonly keywords are represented by the pie diagram shown in the Figure 2.

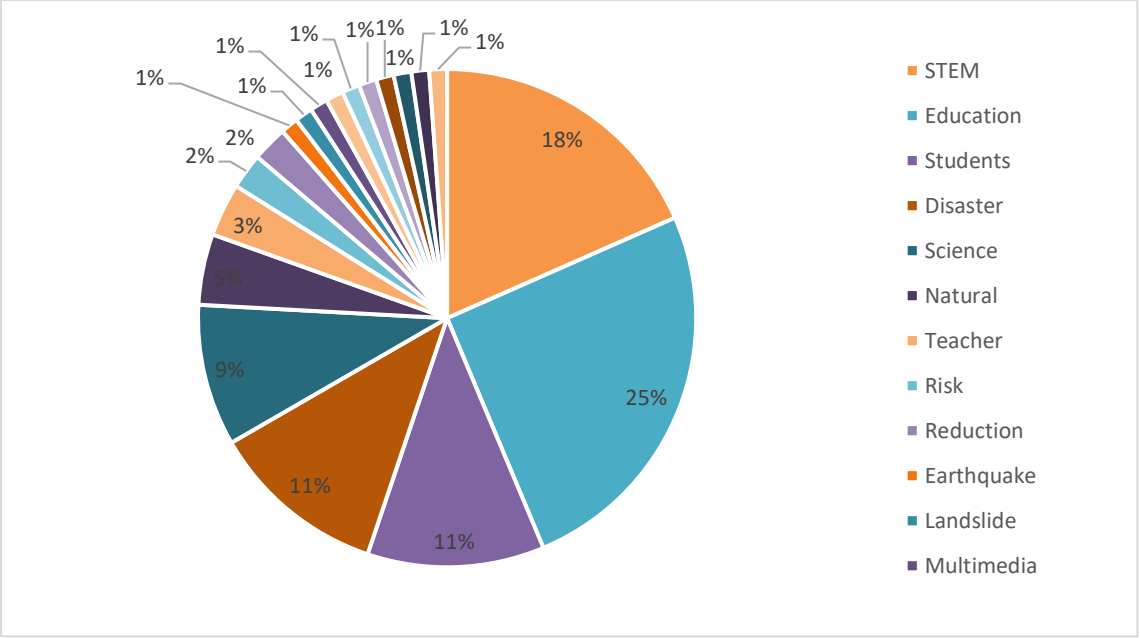

Figure 2. The frequently keywords shown in literature

The words "Education" and "STEM" are the most frequently word arise in those 15 articles with 28% and 20% percentage. Based on those point the involvement of students and teacher in STEM research was rarely conducted, especially for teacher that have lower points which 3%. It is also relevant with [29] that the understanding level of teacher towards STEM still in weak category. Those points indicate that the implementation and learning approach using STEM was rarely done by teacher in their learning to introduce STEM to students. Related to the keywords about disaster which "Disaster" have 11% percentage and some keywords related to it such as, "Earthquake", "Natural" and "Landslide" have a lower point. The specification of disaster in STEM Education in Indonesia represent the geographical condition of Indonesia are vulnerable to disaster so by applying STEM Education about disaster to students can teach disaster education meaningfully, focused, right on the target and have bigger impact for teacher, students, and local community that have poor understanding toward disaster. The implementation of STEM in learning process especially the use of technology is commonly used as

learning media in these keywords, such as "Multimedia", "Digital", "Comic", and "Smartphone-based" are still rarely implemented to students so that the use of technology in learning that uses as an approach and modeling STEM in their learning needs improvement. STEM and learning media can improve students' critical thinking skills [30] and STEM literacy skills [27].

3.2. The Implementation of STEM in Disaster Education

Disaster learning is a main topic relate to disaster prevention and simplify as disaster risk reduction [31]. Disaster education also focusing on the strategy to construct the school-community disaster resilience [32,33]. Disaster resilience is often to integrate with school curriculum to teach students about disaster education. Enhancing school community members' knowledge, risk awareness level, and readiness in responding the future disaster are the main expectation after school integrate disaster education into their school curriculum [32]. Disaster education is one of the internal solutions in community to prevent and minimize the impact of hazard. Disaster education has been made in various format such as disaster mitigation community-base, disaster education leads to communities-awareness of disaster, and disaster management based on their local wisdom [34].

The implementation of disaster education into school curriculum has been made by the educators to prevent and teach students about disaster. Through the observation indicate that teacher is not fully-well understand about disaster risk reduction concept [16]. Disaster risk reduction has not been into the main curriculum of Indonesia education. The disaster education usually implemented into science subject such as science [7], physics [3, 13, 35], and biology [36]. Physics is a subject that studies about the universe and its causes. Earthquake can be taught by integrate wave topic with the process of it.

This study confirmed that STEM as an approach in learning process was an effective way to increasing students' awareness, knowledge, and preparedness towards disaster [32], changing the atmosphere of learning in fun way [20], and able to carry out in online classes [34]. Based on Table 1, it is known that the STEM-integration in disaster education learning media which can be in the form of interactive media including text, video, images, and audio can increase students' disaster awareness. Moreover, students critical thinking abilities can also improve by learning using attractive media [30] and the weak level of understanding towards STEM can increase, so that students ready to solve daily life problem related to STEM. The integration of STEM in preventing disasters has also been carried out by [8] using STEM-D (Science, Technology, Engineering, Mathematics, and Disaster). Local community literacy about STEM and disaster can improving by various studies from non-STEM fields, such as the studies from psychology sector to manage post-disaster traumatic for the community after the disaster. However, the integration of STEM in disaster learning media should be implemented by developing learning media which can include audio-visual such as Virtual Reality (VR) technology. Indeed, VR technology can improve students learning interest towards physics topic [29].

4. Conclusion

The results of this literature review study indicate that the implementation of STEM as an approach in the development of learning media is an effective way to improve and increasing students and teacher understanding, and also give students interesting vibes of learning. Teacher and knowledge about STEM still need to be improved. Through this research, it is known that the use of STEM as an approach to develop learning media is limited. The development of learning media to teach disaster education need to be reviewed and adapted to the geographical conditions of Indonesia, several topics about disaster as recommendation for learning is disaster that often afflict Indonesia such as earthquakes, natural disasters, and landslides.

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