A Qualitative Study: Physics Concepts Used by Survivors in the 2018 Tsunami in Palu City

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Abstract. This study aimed to identify and examine the Physics concepts used by victims of the tsunami disaster in Palu City based on the earthquake, tsunami and liquefaction events that occurred on September 28, 2018 in Palu City. This research was descriptive qualitative. Data were collected by observation, interviews and documentation. Based on the results of the study, the researchers found several Physics concepts that were applied when the victims made efforts to save themselves from the tsunami. These findings were discussed and grouped according to the theme of the Physics concept, including: the concept of speed and velocity, Newton's Second Law Concept, the concept of floating objects, and the concept of waves. The results can be used as a contextual example in learning physics. By doing so, the students will not only learn about Physics concepts, but also improve their understanding and awareness of local disasters.

1. Introduction

One of the major active faults in Central Sulawesi is the Palu-Koro fault, which according to Tjia [1], has a length of 300 km. The fault is capable of generating the greatest seismic risk and earthquake [2]. Previous studies indicated the risk of frequent earthquakes by the fast slip rate of the Palu-Koro Fault [3]. The estimation of slip rate of this fault is around 35 ± 8 mm year⁻¹ [4]; 38 ± 8 mm year⁻¹ [5]; and 40 mm year⁻¹ [6]. These numbers indicate how this fault is highly active. Before the 2018 disaster, seven destructive earthquakes had occurred in Central Sulawesi within a decade, in 1905, 1907, 1909, 1927, 1937, 1968, and 2012 [7]. The potential of other earthquakes in this area is inevitable.

As Central Sulawesi is highly prone to earthquakes, tsunami hazard is also inevitable. For instance, when the hazardous disaster that hit Palu City in September 2018 for example, the tsunami occurred in less than 5 minutes after the major earthquake. It was a short-range tsunami or a local tsunami based on the time span between the main shaking and the tsunami which has a very fast arrival time of between 0-30 minutes.

However, most of the locals have a low risk perception associated with the tsunami. It is owing to the frequent minor earthquakes that have happened in Palu which were not followed by tsunamis. Accordingly, they believed that the area of Palu Bay is safe from this hazard. This low awareness of disaster risk perception is unfortunate since Central Sulawesi has the highest frequency of tsunami occurrence in Indonesia. In Palu City alone, before the accident in 2018, a tsunami that was triggered by the Palu-Koro fault, had happened four times in 1927, 1968 and 1996. Their arrival time was also less than 10 minutes. However, they were not well recorded. Documentation of the past natural events
is significant for both the disaster-related studies and disaster-awareness dissemination activities. Fail to document the past events will affect the continuity of information dissemination.

In addition, disaster experiences that do not have a significant impact on victims can lead to reduced awareness of disaster risk in individuals [8]. For example, people fled to high places when a major earthquake occurred in 2005. Fortunately, it was not followed by a tsunami. However, it could drive individuals to believe that the future disaster will not be a big risk, or they will be able to overcome the risk caused by the disasters [9]. The different experiences while confronting natural hazards might cause different disaster risk perception, awareness and preparedness among locals regarding the potential occurrence of a tsunami. Therefore, it is imperative to sustain the information about the past events thus it can be used to raise awareness for the next generation about the disaster potential in their areas.

Based on the active movement of the Palu-koro fault, the potential for a tsunami in Palu Bay in the future is very high [10]. Therefore, this study aimed to record the stories of the tsunami’s survivors and relate their stories to physics concepts. The results of the research are expected to be archived in the form of data and documentation of the tsunami history in Palu City. In addition, the stories of the survivors can be utilized in learning about disaster awareness since bringing contextual and familiar cases to students should be used as the key in disaster education [11].

2. Methods
This study was descriptive qualitative research, which examined facts about the physics concepts used by several survivors while escaping from the tsunami disaster in Palu City. Data divided into primary data, which were collected through observation and interview techniques, and secondary data through literature study and documentation related to the tsunami in Palu City. The selection of respondents used purposive sampling, especially those who have had direct experience during the 2018 tsunami. Some respondents were obtained from social media posts which were then offered for research interviews. The were 5 respondents (with various age ranges of 20 to 60 years), 2 men and 3 women. The data from the interviews were analyzed through three stages, namely data reduction, data presentation and conclusion drawing. The data were in the form of stories and were analysed from the perspective of physics concepts.

3. Results and Discussion
3.1 Speed and Velocity Concept
Speed and velocity concepts were based on the path taken by the survivors. The paths are illustrated as Figure 1. Kesya (17 years old) ran through the highway that was not perpendicular to the direction of the waves, and was hit by the waves. Meanwhile, Kesya's sister was not hit by the waves because she run through the old building which was perpendicular with the direction of the wave. From the story, the concept of velocity and speed applied. In terms of physics concepts with the same mileage, Kesya and Kesya's sister get different displacements. It can be said that with the same velocity, Kesya had smaller velocity than the direction of the tsunami wave, while Kesya's sister had a higher speed than the direction of the tsunami wave.
Figure 1. An overview of the paths taken by survivors

3.2 Floating Object Concept
Survivors used various efforts to save themselves from the waves. Some survivors managed to save themselves using trash cans to stay on the surface of the water. For example, a survivor stated that he was drowned multiple times by the waves before he grabbed a trash can. It helped him get an upward force or a buoyant force. In this situation, the survivors could stay afloat on the surface of the water without swimming or performing any movement that could drain their energy to stay on the water surface while trapped in the tsunami waves, at least until the tsunami waves recede or until help from the rescue team arrives.

3.3 Newton II Law
A survivor explained that she took off her shoes to get a wider range of motion and run faster. It applies to the concept of physics as stated in Newton's second law, where the acceleration of an object is directly proportional to the force imposed on it and inversely proportional to its mass. Conceptually, removing the shoes worn by the survivors is the same as reducing their mass. By reducing its mass, the force required to move or to run is becoming smaller. Then with this smaller mass, the survivor can increase the force and acceleration. Especially when they were hit and rolled by the waves, the survivors got more space and it made it easier for the survivors to swim up to the surface.

3.4 Wave
An amateur video about a ship caught in the tsunami waves indicated that the captain tried to head towards the middle of the sea or away from the coastal area. It implied that the concept of physics applied to this event is the concept of waves. As seen in the incident recorded in the video, the ship that will be leaning against the pier changes course away from the pier or the coast because they understand that on the coast, the tsunami waves become higher than in the middle of the sea. By directing the ship away from the pier, the height of the waves hitting the ship will be lower.

In Physics, tsunami waves can be explained from the phenomenon of transverse propagation of waves; its energy is a function of its height (amplitude) and its velocity. Its height is greatly influenced by its wavelength (see the comparison of depth, velocity and wavelength in Figure 2). Tsunamis have wavelengths of hundreds of kilometers, but in deep oceans behave like shallow-water waves. As a result, people who are on a ship sailing in deep sea or ocean will not be aware of a tsunami.
The closer you get to the mainland or when you are at a shallower sea depth, the wavelength will decrease. However, the energy present in the waves will not decrease much. This is in accordance with the relationship between the rate of energy loss (energy loss rate) in the traveling wave is inversely proportional to the wavelength. It depicts that the larger the wavelength, the less energy will be wasted and the energy in a tsunami wave can be considered constant. Since the energy is constant, decreasing the speed will make the wave height (amplitude) increase.

Based on the descriptions of the results, there are some physics concepts used by survivors to save themselves. Referring to the opinion of Saleh and Pendley [11] who suggested that the inclusion of disaster cases should be a center for learning about disasters, incorporating victims’ stories in Physics concepts as previously mentioned is reasonable. It is in line with Rae’s statement [12] that an accident or a disaster experience should be a part of the core of safety curricula. Moreover, since the study of Wulandari et al [13] found that the linkages between tsunami-related topics in textbooks used by schools were not very relatable to the real-life situation, incorporating a real-life tsunami situation could be fruitful for students’ better understanding about the events. Further, including disaster experience cases into Physics concepts will benefit in some ways. First, contextual cases increase student engagement because it is able to connect real-world events with what is being learned, and improve the relationship between what students know and what they will learn [14,15]. Second, while studying Physics, students also learn about disaster risk and safety.

4. Conclusion
Based on the analysis of some events and behaviors of survivors during survival attempts from tsunami, some can be related to physics concepts, consisting of the concept of speed and velocity, Newton’s Second Law, floating objects and waves. The results of this study can be used as the linkage between physics, disaster and real-life situations. Despite the positive suggestion about the real-life situation inclusion into learning process, further investigation on how the influence of real-life hazardous experience on both the physics and safety and disaster learning is necessary.

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