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Students' misconceptions on the concept of sound: a case study about *Marinyo*, Tanimbar Islands

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ABSTRACT

Marinyo is a culture left by the Portuguese around the 15th century in Maluku. The purpose of this study was to find out to what extent students' misconceptions about the concept of sound in the *Marinyo* case in the Kepuluan Tanimbar Regency. The method used was a qualitative study in ethnography in ten villages in two sub-districts. In addition, they conducted a survey in the form of a diagnostic test in the form of questions related to the *Marinyo* case on 300 elementary school students. The findings in the field show that students experience relatively high misconceptions. It was because teachers did not accustom students to learn from natural phenomena around them and were given scientific questions to seek, find and provide answers and solutions related to these natural phenomena. The teacher was more pursuing the conditions and problems of physics in textbooks and less exploring contextual matters. Future researchers are suggested to develop physics or science teaching materials based on regional local advantages that are oriented towards understanding concepts, mental models, critical thinking, problem-solving, creativity and innovative thinking so that teachers and students can learn well so that knowledge of science becomes better.

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1. INTRODUCTION

In order to effectively reshape one's prior knowledge into scientifically understandable and acceptable, it is necessary to identify and address their knowledge. According to the theory of conceptual change, we may want to replace existing reasoning, rearrange, refine or rebuild it during the learning process [1]. This situation is called a cognitive concept or conceptual change. Conceptual understanding is an internal representation, which acts as a structural analogue of a situation or process. Its role is to explain individuals' reasoning both when they are trying to understand discourse and when they are trying to explain and predict the behaviour of the physical world [2].

Most students still experience high misconceptions about physics and physics learning which is very different from the views of physicists. They reported that some students viewed physics as pieces of information studied separately. In contrast, others saw physics as a coherent set of ideas to be studied together [3]. Some students perceive studying physics as memorizing formulas and problem-solving algorithms. In contrast, others think that learning involves developing a deeper conceptual understanding. The University of Maryland uses the term 'cognitive expectations', which means expectations about understanding the learning process of physics and the structure of learning physics [4]. 72 Articles identifying misconceptions across disciplines to assess student understanding [5]. In addition, 111 articles

from 2015 to 2019 that focused on student misconceptions across disciplines, namely physics, biology, and chemistry. Understanding the complete concept of physics will help students work on problems with varying difficulty levels [6].

Misconceptions as scientifically inaccurate interpretations with erroneous ideas and views [7]. Misconceptions come from various sources; students, teachers, textbooks, and the environment [8]. In formal education, scientific misconceptions have been found through interactions between teachers and students who may experience misconceptions in the learning process [9]. Teachers must understand students' misconceptions in learning and improve students' conceptions correctly [10]. Teachers are expected to have good knowledge to help and direct students to better students' scientific concepts [11]. One important factor that hinders meaningful and beneficial learning for students is misconceptions [12]. Misconceptions are based on faulty thinking [13]. Students come to class with fragmented and incomplete knowledge and are always held by students [14]. This situation is an obstacle for them to learn the correct academic concepts. Suppose students are desired to stop the misunderstandings they have and tend to academic concepts, first of all. In that case, these misconceptions must be identified [15]. Several methods have been used to determine misconceptions in interviews, tests, drawings and predict-observe-explain (POE) [16]. Students realize that difficulties and misunderstandings are obstacles to reconstructing scientific knowledge, especially when students learn the concept of sound [17].

Misconceptions about sound have been studied in primary and secondary education. First, misconceptions about sound are expressed in scientifically unacceptable mental models of the nature of sound, as well as concerning certain aspects of sound, such as relating pitch (frequency) and volume (intensity) and/or distance travelled, assuming that the frequency depends on the propagation medium or the assumption that the speed of sound depends on a different one, such as the speed of the sound source, frequency or intensity [18]. In addition, studies on high school students revealed that sound is an invisible object with dimensions that require space to move or sound is air [19].

Most physics scientists have detected students' misconceptions about sound. They do to find out and detect students' misconceptions is a diagnostic test like that done to students in Taiwan [19]. Diagnostic test to measure students' misconceptions in a mental model with three levels, namely surface, matching, and deep (SMD) for high school students in Malang City, Indonesia [20]. In addition, diagnostic test to measure students' misconceptions about the concept of waves [21]. The first-year measures the reasoning of physics students, and the second year measures wave mechanics. Correlation analysis showed that the first-year students did not apply the wave concept consistently. Second-year students seem to apply the concepts fairly consistently to questions about the superposition and motion of particles in sound waves, but not to questions about reflection. These exercises help students develop cognitive skills to understand better abstract physics cases that are still difficult to solve.

In this study, different things are displayed. The measurement and students' understanding of sound on things were still general. For instance, students knew that speakers produced sound to provide information. There is something different about the Tanimbar Islands Regency. In providing information for the community members. In the village, they do not use speakers but use human voices. The person given the task to provide this information is called *Marinyo*. Almost all areas in Maluku used to use the services of *Marinyo*. However, this phenomenon or activity has disappeared due to the emergence of speakers. In the Tanimbar Islands, the *Marinyo* culture is still sustainable today. *Marinyo* can shout at a specific frequency and can be heard well by the community in providing information about village developments. A diagnostic test was given to students to measure the extent to which students' understanding of the particular sounds of the *Marinyo* case was given to measure students' conceptual understanding of *Marinyo*. From the explanation, the purpose of this research was to find out the extent of students' misconceptions about the concept of sound in the *Marinyo* case in the Kepuluan Tanimbar Regency.

2. METHOD

The type of research used was in the form of a qualitative study, namely ethnography. This research traced the culture and community activities that were still sustainable and well maintained. The research was conducted by conducting in-depth interviews with people considered important informants in data collection. The data collection technique was in the form of a snowball, namely visiting the local government, which had the authority to permit data collection and interviewing agencies related to *Marinyo* culture. Next, they directed and guided to enter the targeted villages. It was essential to ensure the researchers could reach the village and had no obstacles. Then, the researchers could be served well, and the research objectives could be achieved. In addition, a survey was also conducted in the form of a diagnostic test for elementary school students to measure students' conceptual understanding or misconceptions regarding the concept of sound for the *Marinyo* case.

The research was conducted qualitatively in ten villages in two sub-districts. The informants who met were the village head village officials who carried out direct discussions at the village hall. In addition, the village head recommended some elders who were considered to have a lot of experience and knowledge about *Marinyo.* There were also interviews with *Marinyo*, who had served for decades. Another activity was a diagnostic test for 300 elementary school students in Ten Elementary Schools in the Tanimbar Islands Regency. Before taking the test, a small question was asked, namely, "do you all know what *Marinyo* is?". It was to lead them to the measured goal.

The conceptual diagnostic test instrument refers to the rubric developed by Furtak *et al.* [22], which includes 4 aspects: not conceptual, no logical conceptual, conceptually based on data, conceptually based on evidence, and logical and sequential conceptual based on inductive-rules deductive. The questions developed were in the form of 5 questions that require 1-4 complete student answers with various points of view. Before testing the students, three experts validated the instrument, namely theoretical physics and learning physics, from Pattimura University. In addition, a structured interview instrument in the form of 15 questions to informants was used to obtain good information about *Marinyo*. Two cultural sociologists also validated this instrument from the Faculty of Social and Political Sciences from Pattimura University. The latter had done much research on *Marinyo.*

The data analysis technique was carried out in interviews with informants, then analyzed and reconfirmed with experts who had done much research on *Marinyo*. In addition, relevant sources were looked for to reconfirm, so there were no errors when reporting was done. The survey data in the form of test results were then corrected, analyzed and mapped according to the instruments from the recommended experts to get a profile of students' misconceptions about *Marinyo*.

3. RESULTS AND DISCUSSION

3.1. What is sound?

Sound is a mechanical vibration of a continuous medium. It requires a good understanding of classical and modern physics [23]. Sound is caused by the movement of vibrating particles that can cause friction with the surrounding substances. The vibration of objects or air touches the particles of substances nearby in the form of gases, liquids, or solids, depending on the location of the vibrating object. The loudness of sound is strongly influenced by the sensation caused to a person's hearing. Loudness increases as the intensity increases, but this increase does not occur linearly. The greater the amplitude, the louder the sound produced will be more excellent [24]. Sound is a wave propagation from one point to another or a physically propagating object moving from one location to another [25]. In addition, the sound is formed by molecules bouncing off surfaces. Sound will travel faster if it does not meet any object in the air. Sound travels faster because the density of solid objects is smaller [26].

Sound has many functions, one of which is communicative in providing literal and nonliteral information. Literal sounds convey meaning that refers to the listener's source of the sound [27]. For example, hearing footsteps refers to hearing someone walking or running. On the other hand, nonliteral sounds are disconnected from the source or nondiegetic sounds. It means that the audience cannot see and refer to the source that created the sound [28]. Sound waves in the air are longitudinal waves that are periodic [29]. Figure 1 represents the models, and the differences can be depicted like a cartoon [30]. Here, the human character represents the air particles, and the ball represents the sound entity. These models are A) Wave Model, which is a scientifically accepted model, B) Propagating air model (hybrid model), C) Dependent entity model (hybrid model), D) Independent entity model, which is a dominant alternative model.

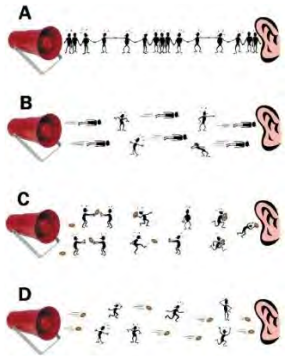

Figure 1. Sound models

Sound is a motion of particles moving in the air [31], as shown in Figure 2. The findings in Spain show that students' mental models of the concept of sound still show great misconceptions even though they have made simple pictures [32]. Sound is taught at the University, but this topic is challenging to learn. Albert Einstein said that imagination is more important than knowledge. Knowledge has a limited scope, but imagination covers the whole world and all that has ever existed to know and understand [33]. Sound as particle motion can be shown in Figure 2.

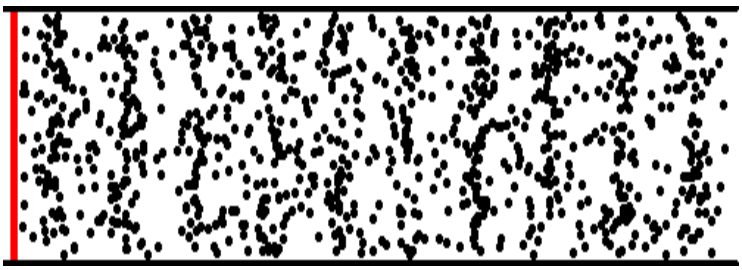

Figure 2. Sound as a movement of particles

3.2. What is *Marinyo* to the archipelago community in Maluku?

Marinyo was taken from the Portuguese language, namely *Meirinho*, which is an assistant to the captain, who serves as a spokesman who conveys instructions and decisions to the people or in other words he is the "mouth of the king" [34]. This term emerged after 1512. *Marinyo* had a kind of rank in the village community, even though he was not included in the high class or nobility and held a hereditary position. *Marinyo* also serves as assistant to the head of *Soa* and serves as a bodyguard. The village government appointed *Marinyo*. This tradition is a cultural heritage in Maluku, but this culture is getting lost. In the Tanimbar Islands, *Marinyo* still applies this ancestral culture. *Marinyo* must go around the village to deliver news to the community. Apart from that, *Marinyo* is also tasked with gathering citizens or children of the *negeri* when there will be a traditional event or emergency by ringing a *kentongan* and blowing *Tahuri* or large shells like a trumpet. Usually, *Marinyo* shouts, or *Tabaos* gives information to the village community in the late afternoon. It is done because when it is late in the evening, the people have returned from their gardens and gone to sea so that the community can hear the information.

The student record data in Table 1 displays the results of student answers that are fully informed. This data is displayed in providing conceptual information on sound, especially *Marinyo*. Some students were able to answer several questions with four alternative answers. The data in the field provides information that students who had a good conceptual were due to parental support factors in facilitating children's academics. On average, in addition to studying at home, children were given online science courses so that they helped and improved their learning outcomes. In addition, children who live in cities have a good mental model compared to children who live in rural areas. Living in a rural area with a lack of facilities, the unavailability of supporting devices such as laptops or cellphones in finding information to increase physical literacy. This is in line with the results of previous studies, which showed that parents play an important role in children's academic achievement in the form of grades and other academic targets to be pursued and achieved [35].

Marinyo shouting in giving information to the public is shown in Figure 3. The sound pressure from *Marinyo*'s mouth gives force. This force generates an elastic wave in a longitudinal wave, resulting in back and forth motion. This movement produces a pressure sound that is detected by the listener's ear.

Formal education in Macedonia starts from the age of 6-7 years. At the end of elementary school education, students were given lessons that equipped their physics concepts before junior high school. The materials provided are dynamic electricity, static electricity, sound, light, atomic structure, isotopes, types of radiation, and radiation and its application [36]. Teachers believe these materials will equip them at the top level. The results of a previous study in Turkey to 470 science teacher candidates in the form of a diagnostic test in a Four-Tier Misconception Diagnostic Test showed that 48 misconceptions were revealed. It was suggested that tests were also conducted on secondary and higher education students. Experimental and virtual studies should be carried out to dispel misconceptions [37].

Table 1. Recorded student answers

Questions	Student answer	Respondents
Why can people hear the voice of Marinyo screams?	1. Marinyo produces a high-frequency sound. 2. The distance between Marino and the community is not far. 3. The presence of reflective media in houses from walls or mountains can reflect sound to listeners. 4. The great energy produced by the Marinyo.	S45
In your opinion, what breathing is used when *Marinyo* screams, chest breathing, or belly breathing?	1. In chest breathing, the muscles between the ribs expand (contraction) when inhaling (inspiration) and contract again (relaxation) after exhaling so that the resulting sound is immense. 2. In abdominal breathing, the diaphragm muscle contracts during the inspiration process and relaxes when exhaling air so that the sound produced is slight. 3. *Marinyo* is more stable in chest breathing and does not need much energy to produce sound. 4. Abdominal breathing can open the blood vessels in the lungs so that more oxygen enters the blood. This condition will impact the increasing concentration and mental capacity of Marinyo.	S67
When *Marinyo* makes a sound, why should his mouth be circular shape?	1. Form a circular pattern to produce an immense sound spreading to all directions due to the air expulsion from the inside. 2. Establish a high frequency. 3. Produces significant air repulsion. 4. Taking sufficient oxygen in the air.	S100
Why would *Marinyo* prefer to shout at night rather than during the day?	1. The density of particles at night is denser. 2. Sound sources from the environment are lost, and only one sound source is heard. 3. The temperature in the air decreases so that sound travels faster. 4. During the day, the air temperature increases to suppress the sound to slow down.	S250
Why do *Marinyo* choose to scream at an altitude position?	1. Objects in front do not block the flow of particles in the form of waves. 2. Air particles will push the sound to move faster. 3. The resulting sound particles do not cancel due to reflections. 4. The density of the air at high altitudes is better so that the sound particles are lighter and the air quickly transports the bottom.	S4

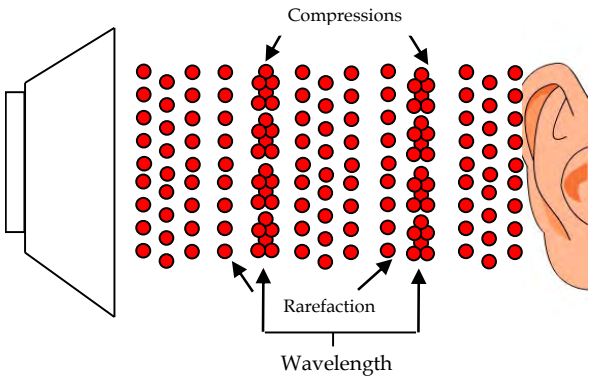

Figure 3. Simulation of sound waves from source to listener in the form of longitudinal waves

The findings of sound for elementary school students in the Tanimbar Islands still have high misconceptions. From a total score of 100 out of 5 questions, students can achieve a score of 15.83. This situation is something that needs to be seen. Students always see and relate directly to *Marinyo*'s activities, but they find it challenging to connect scientific concepts. On the other hand, the teacher does not provide scientific information to students. On average, teachers only give or teach students in physics in textbooks. The teacher forgets that the real learning of physics is to introduce the world around as a good learning laboratory. In addition, many science teachers do not teach conceptually. Instead, they prefer algorithmic or mathematical teaching. Such learning can improve students' algorithms in problem-solving while conceptual understanding is not developed or is weak. In addition, teachers find it difficult to translate or transfer knowledge in scientific language that is good for students to understand. Teachers have high misconceptions [38]. Suppose students' misconceptions are not appropriately handled. In that case, it will have a significant impact when children are in society and the world of work.

The study of physics cases in the last three decades is marked by the number of students who find it challenging to study physics. It is because learning physics is not good when given by the teacher. Learning is still traditional and does not stimulate higher-order thinking skills. Consequently, when students are given questions related to surrounding phenomena, students will find it difficult to answer. Even if they answer with various answers, some are complete, some are wrong, some are still in simple terms [39], [40]. The process of shifting from a wrong scientific understanding to a correct understanding is strongly influenced by what the learner already knows. The learner's priority should always be involved when trying to understand new information. This situation then requires cognitive reorganization in the brain to accommodate the new information [41]. Misconceptions are detrimental to students, and the average is in younger students. In addition, students' cultural background and lack of physical literacy also affect misconceptions [42]. Students tend to form the concept of light based on their daily experiences and build a belief system that very often contradicts scientific theories to affect student academic achievement.

Sound is a substance that cannot be seen with the naked eye. Sound is microscopic and cannot be adequately understood. Therefore, learning media is needed that simulates things that are still abstract so that they can be explained to students in a concrete way. Moreover, in this case, the sound is described by *Marinyo*, who only screams, and the effect is that the public can hear it. Simulating sound so that it reaches the listener is very difficult to explain. Therefore, teachers must use assistive media in the form of animation or audio-visual media to explain the phenomenon well to students. The previous findings provide information that learning is based on lectures and students only take notes, so the contribution to mastery of the material is only 5%. If it is continued with reading, it contributes 10%. Learning with audio-visual aids will contribute to mastery of the material by 30% (The Higher Education Academy) [43]. Suppose students can visually see biological material in microscopic form. In that case, students will understand it more efficiently and avoid the construction of misconceptions. Visualization of the movement of sound particles also increases, so students will easily understand and develop more meaningful concepts. The results of physics research in Bhutan revealed that the average score of students' physics misconceptions was 52.60 [44]. It is because students find it difficult to explain an abstract phenomenon. Misconceptions should not be regarded as something frightening but rather as an opportunity for students to incorporate new knowledge and act as a starting point for building new scientific understanding from a constructivist point of view. Misconceptions may still exist even though learning has been carried out in eliminating student misconceptions. Misconceptions will continue to exist in primary, secondary and higher education. The simulation of sound waves can be shown in Figure 3.

When the speaker diaphragm vibrates back and forth, it will disturb the surrounding air molecules. The air molecules then pass on the reaction to adjacent air molecules. In this way, the vibration waves coming from the speakers travel through the air molecules as sound waves. The air molecules themselves do not move from the speaker to the ear but only vibrate to and fro. It is because air molecules move in the same direction as the waves. Accordingly, sound waves are longitudinal waves. Wavelength is the distance between successive compressions or rarefactions. Compressions are regions in a wave where air molecules are pushed close together and at slightly higher pressure. Rarefaction is areas in the wave where the air molecules are further apart at a slightly lower pressure.

The results of previous studies for junior high school students in Ambon City for learning physics in solving mathematical equations and solving problems still experience high misconceptions. Disruptive factors that make high physics misconceptions are motivation, interests, knowledge, and basic skills [45], [3]. High misconceptions will result in academic failure in specific fields affiliated with physics such as science, technology, engineering, and mathematics (STEM), resulting in a high decline. The results of studies in the United States provide information that only 57% of engineering graduates complete their studies. Due to the complexity of high misconceptions that interfere with poor academic performance [46]. Misconceptions also interfere with meaningful learning. In addition, misconceptions can penetrate the walls of students' cognition and are very difficult to change [47]. Even if they change it, the environment also affects the change for quite a long time. Field data shows that students experience relatively high misconceptions in sub-sounds, and can be shown in detail in Table 2.

Table 2. Student misconceptions for *Marinyo*

Marinyo's misconception with microscopy	%
Sound can be heard	55
Breathing used to scream	57
Mouth shape when shouting	65
Scream at night instead of morning	75
Shouting position	77

Students assume that sound is a wave that transports matter. On the contrary, natural science says that sound transports energy from one position to another. Sound has atoms or constituent particles that are tightly packed and always move depending on the frequency produced from the sound source. In longitudinal waves, atoms collide with neighbouring atoms and transmit energy. The sound propagates until it reaches the eardrum. The energy flows into the tiny hairs inside the ear. A vibrational pattern is generated in the ear and interpreted as a particular sound by our brain [48].

In addition, according to students' thinking, the speed of sound can be blocked by the medium through which it travels. The density of the molecules propagating in the medium increases the resistance. Since there is no resistance, heat affects the speed of sound. In addition, students cannot determine the relationship between sound frequency, wavelength and period and between sound frequency and proper thickness and thinness [49]. The study results show that there is a significant relationship between heat and sound. However, this significant relationship is sometimes weak [50].

4. CONCLUSION

Based on the findings and discussion, students still experience misconceptions regarding the concept of high sound related to *Marinyo*. Teachers did not accustom students to learn from natural phenomena around them and were given scientific questions so that students could seek, find and provide answers and solutions related to these natural phenomena. The teacher was more pursuing the conditions and problems of physics in textbooks and less exploring contextual matters. If this situation is not quickly resolved, students will experience embedded misconceptions. They will be bottomed out at higher levels, society and the world of work.

Future researchers are suggested to develop physics or science teaching materials based on regional local advantages oriented to understanding concepts, mental models, critical thinking, problem-solving, creativity and innovative thinking so that teachers and students can learn well so that knowledge of science becomes better. Nature provides various advantages, but human resources are still weak and challenging to explore. One of the factors is conceptual science which is still low. It makes it challenging to develop the existing nature for the life and welfare of many people. This research implies that teachers, researchers and related institutions can get information and input in the future development of students' science to produce superior, productive and resilient human resources. In addition, teachers can improve scientific literacy through lots of exercises and training in improving teacher competence.

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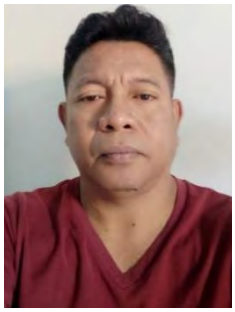

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