Understanding the prospective physics teachers conception of the characteristic of sound

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Abstract. This study aimed to analyze the level of conceptual understanding of prospective teacher students of sound characteristics. This research was descriptive. The subjects were students of Physics Education at Sriwijaya University and Lambung Mangkurat University who participated in wave courses totaling 69 people. The data were collected using a previously developed diagnostic test instrument and modified according to research needs. The data were analyzed using descriptive statistics. The results showed the percentage of conceptual understanding possessed by the respondents (1) 52.17% on pitch and loudness of sound waves from two people shouting simultaneously; (2) 42.11% on the speed of sound wave propagation; (3) 2.90% on the wave superposition concept; and (4) 5.80% on sound reflection. There are still misconceptions occur, the velocity of propagation of sound waves is influenced by the amplitude and frequency of the sound, and a dust particle in front of the sound source will move influenced by the sound's loudness. Overall, the level of conceptual understanding of some of the characteristics of sound wave concepts varies, and alternative concepts are still emerging, so it needs learning innovations to overcome these problems.

1. Introduction

The problem that often occurs when studying physics is identifying a problem in certain circumstances and solving it using the physics concepts that they master [1]. Apart from the inability to use physics concepts to solve problems in certain circumstances, the lack of mathematical skills is also an obstacle in studying physics [2]. This problem is an example of physics; another example of a problem is the poor understanding of concepts both students and prospective teacher students on mastery of physics concepts.

The discussion of conceptual understanding becomes an interesting issue because physics is closely related to everyday life [3,4]. One of the exciting physics concepts to learn is understanding the concept of sound waves. Sound waves are mechanical waves whose direction of propagation is parallel to the vibration's direction, so sound waves are longitudinal waves.

Research on understanding the concept, and how to solve it related to waves has been done before. These studies reveal the conceptual understanding of both students and students on several wave concepts, especially mechanical waves, one of which is about sound waves [5–10]. The research that has been done also discusses how to solve problems related to understanding the concept of waves and its implementation in physics learning [11–13].

Some of these studies stated that understanding students' concept of waves still requires hard work to teach it. The concept of waves discussed includes propagation, superposition, reflection, and standing
waves. However, the results showed that students' understanding of waves' concept still varied and could not be separated from the emergence of misconceptions. According to scientists, misconceptions or alternative concepts are gaps between the conceptions that students have and the correct conceptions so that it triggers students' poor understanding of concepts.

An alternative concept that usually occurs when studying wave material is the concept of the Doppler effect. One of the reasons is students assume that changes in frequency occur due to changes in the distance between the source and listener. Nevertheless, these are not due to the relative distance between the listener and the source. Besides, students also assume that the wave propagation velocity is influenced by the amplitude, not by the medium's characteristics [14]. Several other misconceptions occur in the concept of waves, especially regarding the characteristics of the wave, the frequency and source of the waves, and the properties of the medium [15,16].

This research is follow-up research that is expected to provide an overview of concept understanding, especially prospective teacher-student about sound waves' characteristics. Discussion on understanding the concept of sound waves is essential because there are many conditions around students who use sound. The simplest example of a phenomenon related to sound waves is an explanation of the process of hearing. Based on the explanation that has been stated, this study aims to analyze the level of understanding of the concept of prospective teacher students regarding the concept of sound wave characteristics.

2. Method
2.1. Research design, setting, and research subject
The research was conducted using descriptive methods to analyze the level of understanding of prospective pre-service teachers' concepts of sound waves' characteristics. Since the Indonesian National Qualifications Framework (KKNI) implementation, the physics education curriculum in Indonesia uses standard graduate outcomes that have been mutually agreeing upon based on the results of discussions between heads of physics education study programs throughout Indonesia. The research subjects were pre-service teachers in the Physics Education Study Program, FKIP Sriwijaya University and Lambung Mangkurat University, who participated in wave courses totaling 69 people. More specifically, the research subjects consisted of 20 Physics Education students of Sriwijaya University Palembang class, 29 Indralaya Class Sriwijaya University Physics Education students, and 20 Physics Education students of Lambung Mangkurat University.

| Group | Research Subject                        | Number |
|-------|----------------------------------------|--------|
| Group | Physics education students of Sriwijaya University: Palembang class | 20     |
| Group | Physics education students of Sriwijaya University: Indralaya class | 29     |
| Group | Physics Education students of Lambung Mangkurat University | 20     |

2.2. Instrument and data collecting
The data were collected using this diagnostic test consisting of 3 multiple choice questions and 4 description questions. The diagnostic test is a modification of the previously developed diagnostic test instruments, namely the Mechanical Wave Conceptual Survey (MWCS) and the Wave Diagnostic Test (WDT) [10]. The reason is that not all question items contained in the instrument are used. In this study, the WDT and MWCS instruments used were selected according to the concepts to be studied, namely propagation, superposition, and reflection of sound waves. Wave propagation discusses the velocity of propagation, frequency, wavelength, and amplitude of sound waves.

| Concept          | Item Number |
|------------------|-------------|
| Wave propagation | 1,2,4,5,6   |
| Wave superposition | 3      |
| Wave reflection  | 7          |
2.3. **The Data Analysis**
The data obtained were analyzed using descriptive statistics. The data analysis begins with grouping the respondent's answer in each item of the question, then continues by analyzing the correct answer to see the respondent's understanding. The next step is to classify students' level of conceptual understanding into five levels, namely not understanding concepts (TP), experiencing misconceptions (M), understanding concepts but still experiencing certain misconceptions (PK & M), understanding some concepts (PS), and understanding concepts (PK) [17].

3. **Result and Discussion**

3.1. **Research description**

This research is related to the analysis of pre-service teachers' student-teacher conceptual understanding of sound waves' characteristics carried out on 69 respondents. Respondents were students of physics education from two universities, namely Sriwijaya University in South Sumatra and Lambung Mangkurat University in South Kalimantan. The profiles of graduates of the Physics Education at the two research locations have the same characteristics, one of which is to produce prospective professional educators in the field of physics education. This allows the use of the same curriculum, except for certain groups of subjects that are characteristic of each.

3.2. **The result of the wave characteristic diagnostic test**

When discussing waves in general, they have characteristics, including reflection, refraction, diffraction, and interference. In addition, there are also some general terms discussed when studying waves, namely wavelength, frequency, amplitude, and velocity of wave propagation. These wave characteristics also apply to sound waves. Sound waves are a type of wave that requires a medium to propagate, so sound waves are considered mechanical waves. When viewed from the direction of propagation of sound waves, it is a type of longitudinal wave because propagation is in the same direction as the direction of the vibration [18].

When discussing the propagation of sound waves, it cannot be separated from the discussion about propagation velocity. The velocity of propagation of sound waves depends on the propagation medium's properties, namely density, elasticity, modulus, and temperature [19]. Based on the analysis of the answers to question number 1 regarding the fast propagation of sound waves in the air, it was dominated by respondents who did not understand the concept of 42.03%. From 69 respondents, 27.54% answered correctly that the velocity of sound waves was influenced by the medium's properties, in this case, the propagation medium was air. However, respondents who gave correct answers indicated that 42.11% understood the concept; 10.59% understand the concept, but there are misconceptions; and 31.58% had misconceptions. As for alternative conceptions that appear, such as: the velocity of sound propagation is influenced by the frequency of the sound source; the amplitude of the sound source influences the velocity of sound propagation; and the velocity of sound propagation is influenced by the volume of the sound source.

Furthermore, question number 2 asks about two students who were singing very loudly but with different tones. The results of the data analysis showed that 52.17% of students answered correctly, that is, both students have the same amplitude, but different frequencies. When someone sings loudly, it means that the intensity of the sound produced is high. The sound intensity is related to the energy carried by the wave per unit time through the unit area. In addition, the sound intensity is proportional to the square of the sound wave amplitude [18]. While the tone is a characteristic of the waves related to the frequency received by the listener. Another result obtained from the analysis of question number 2 shows that 47.83% do not understand the concept. This shows that more than half of the respondents understood the concept being asked.

Problem number 3 asks about the resultant two wave pulses after 2 seconds, which move toward each other at the same speed, and the motion starts at t = 0 seconds (Figure 1). The discussion regarding question number 3 is related to the superposition principle of sound waves. Two waves passing together are algebraically added to produce the resultant wave [20]. If the two passing waves have the same
phase, there will be mutually reinforcing interference. The results showed that only 2.90% of respondents answered correctly and understood the concept. Another result shows that 62.32% do not understand the concept because the selected answers' consistency indicates that the chosen answer is correct (Figure 3). Based on the answer choices given, the respondent can determine the propagation of the wave correctly but fails to determine that the given wave pulse has the same wavelength and amplitude so that when the two wave pulses meet, a wave superposition will occur.

![Figure 1](image1.png)

Figure 1. Two wave pulses move close to each other at the same velocity and at t = 0

![Figure 2](image2.png)

Figure 2. The answer choices that many students chose

![Figure 3](image3.png)

Figure 3. The correct answer

The last question asked about someone who shouted within 30 meters in front of the barrier wall; a few moments later, that person heard the echo of his shout earlier. If there are dust particles floating 0.1 mm in front of the barrier wall at that time, how do the dust particles move and the speed of sound is released until an echo is heard. The analysis results obtained that only 5.80% of respondents understood the concept and succeeded in stating that the dust particles would not move because the sound wave pulses were reflected perfectly by the barrier, and the loudness of the sound did not affect the speed of the sound that was emitted. This question was dominated by 47.83% of respondents who did not provide answers. However, there were still 10.14% of respondents who indicated a misconception. An alternative concept that arises related to this question is that respondents consistently stated that the loudness of the sound influences the speed of sound waves propagation, this causes dust particles to be pushed against the wall, and some even stick to the wall.

Overall shows that the level of understanding of the concept of the characteristics of sound waves varies. The concept of loudness and height of sound waves is the concept most understood by respondents, while the lowest understanding of the concept is shown in the superposition of the wave. Besides, there are several misconceptions found in the concept of wave characteristics. These results indicate that misconceptions will still emerge even though understanding of the concept increases. This
is in line with previous research that states that students' understanding of magnetic fields' concept has improved, but there are still some misconceptions [21].

The results showed the need for learning innovations to improve conceptual understanding and reduce misconceptions of wave material which occurred during the learning process. Previous research to overcome these two things has been done using Microscopic Virtual Media (MVM) applications, guided inquiry learning models, and interactive demonstration methods [22–24].

4. Conclusion
Based on the research that has been done, it is concluded that understanding the concept of prospective teacher students on the concept of sound wave characteristics varies. The concept of sound wave propagation shows that 42.11% understand the concept; 10.59% understand the concept but there are misconceptions; and 31.58% had misconceptions. The concept of loudness and the three levels of sound waves shows that 52.17% understand the concept and 47.83% do not understand the concept. The concept of superposition of sound waves is dominated by not understanding the concept of 62.32%. Finally, the concept of sound reflection is dominated by 47.83% of respondents who do not provide answers. The alternative concept most often appears, namely the factors that affect sound waves. However, this study's results are still limited to prospective teacher students at the location where the research was conducted, so it is necessary to conduct the research with a representative sample so that the research results can be generalized to the wider population.

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