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# TEACHING THE DOPPLER EFFECT TO STUDENTS WITH DEAF AND HARD OF HEARING

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**Abstract**

The purpose of this research was to discover how to teach Doppler effect material to students who are deaf or hard of hearing (DHH). The research method used was experimental (pre- and post-test design) for five DHH students aged 17 to 19 years. The Doppler effect lesson was given through modified learning videos according to the specificity of DHH students. The results showed that the material about the Doppler effect could be taught to DHH students. Although they cannot hear well, they understand that the frequency of sound waves heard by the listener can change due to changes in the position of the sound source or the listener. The ability of students with DHH in knowing the material was influenced by the content in the learning videos and the teacher's ability to explain the lesson material. In addition, the ability to read and the ability to communicate are needed to understand the learning material by DHH students.

Keywords: Deaf, Doppler effect, Hard of hearing.

## 1. Introduction

Students who are deaf or hard of hearing (DHH) are constantly in contact with a world full of sounds in their daily lives. As a result, DHH students require hearing training to become aware of their surroundings. Indeed, they need specific treatment [1-7]. Listening exercises are required to improve DHH students' listening skills and communication skills [8, 9]. Sound-related teaching materials can help DHH students become more aware of their surroundings. DHH students are capable of comprehending concepts such as sound waves, sound intensity, and sound reflection because they are also no strangers to basic principles that are related to sound such as pressure and vibration effects [10-13]. The concept of the Doppler effect is another material related to sound. The Doppler effect can be found in all types of waves, including water, sound, and light waves. The Doppler effect in this context is the Doppler effect that occurs in sound waves. As known, one of the most important materials in studying the sound of stationary and moving objects is the Doppler effect.

Research has been conducted on learning and teaching the Doppler effect [14-18] Visual aids have also been developed for the Doppler effect concept, using the ADDIE model for the research design. According to the results of the media feasibility test, the Doppler effect visual aid can be developed as a tool in the learning process [19]. Learning media in the form of a Doppler effect practicum tool aided by Audacity can be used in physics learning [20]. However, there has been no research that discusses how to introduce the concept of the Doppler effect to DHH students in these numerous studies.

This research aimed to discover how to teach DHH students about the Doppler effect. The experimental method (pre-and post-test design) was conducted with five DHH students aged 17 to 19 years. Materials on the Doppler effect were presented via modified learning videos adapted to DHH students.

The results of this study contribute to the world of education, especially regarding the concept of sounds that are applied to DHH children to make it easier to understand through learning videos that are modified and tailored to the needs of DHH students.

## 2.Method

The participants of this study were five grade nine students with DHH ranging from 17 to 19 years old at Junior High Special School. The research method used was experimental (pre-and post-test design) without a control group. This study used a pre-test – treatment - post-test. Students were given an initial test, then given material about the Doppler effect, and a final test when the treatment was finished. The subjects of this research were students with good sound perception skills.

This research was conducted through several stages, namely: 1) providing learning videos about sound and the Doppler effect, 2) students watching learning videos about the Doppler effect, 3) students listening to the explanations in the video, 4) students are explained the learning videos that previously made 5) students are given several questions about the understanding of sound and the Doppler effect, 6) students are given a post-test to assess students' understanding of the material that has been delivered.

All information about understanding the data was assessed using a rating scale; 0 (does not know) and 1 (know). As for the attitude assessment toward the existence of a reflected sound, it is rated with 0 (no), 1 (doubtful), and 2 (yes). This attitude assessment can be assessed through spoken direct answers and student expressions.

To collect data on understanding the material, students were given several statements that must be responded to, whether the statement was true or false, namely:

(i) Sound is produced by a stationary object
Answer key: This statement is false
(ii) Sound waves propagate through a medium
Answer key: This statement is true
(iii) The higher the frequency of the sound, the denser the sound waves
Answer key: This statement is true
(iv) The sound spreads only toward the front side
Answer key: This statement is false
(v) As the source of the sound approaches, the sound gets louder
Answer key: This statement is true
(vi) As the source of the sound moves away, the sound gets louder
Answer key: This statement is false
(vii) The Doppler effect is caused by a change in the position of the sound source
Answer key: This statement is true
(viii) The Doppler effect is caused by a change in the position of the listener
Answer key: This statement is true
(ix) The Doppler effect was discovered by biologists
Answer key: This statement is false
(x) The Doppler effect was discovered by Christian Andreas
Answer key: This statement is true.

During the teaching and learning process, the researcher observed students' attitudes and expressions when the Doppler effect was being explained. The indicators used are:

(i) Student pays attention when the material is taught
(ii) Student demonstrates an understanding that as the source of the sound approaches, the sound gets louder
(iii) Student demonstrates an understanding that as the sound source moves away, the sound becomes less audible.

## 3. Result and Discussion

### 3.1. Student's demographic data

This study involved five grade nine students with DHH ranging from 17 to 19 years old at Junior High Special School. Student A, a 17-year-old girl with severe hearing loss uses spoken, written, and sign language to communicate every day and has good oral language skills. The student got a 90 for science and a 92 for Development of Sound and Rhythm Perception Communication (PKPBI). The student's sound perception ability is at the stage of sound detection and discrimination. The student is aware of the presence or absence of loud sounds.

Student B, is an 18-year-old female with severe hearing loss and has good interpersonal skills and communicates using oral, written, and signing in everyday life. The student got a 90 for science and a 92 for Development of Sound and

Rhythm Perception Communication (PKPBI). At the stage of sound detection and discrimination, the student can perceive sound. The student is aware of the presence or absence of sound, but only with a loud voice, as in realizing the sound of a table being hit.

Student C is a 17-year-old female with mild hearing loss. The student can hear when her name is called. The student got 88 for science and 90 for Development of Sound and Rhythm Perception Communication (PKPBI). To enable sound detection, the student is aware of the presence or absence of loud sound. The student uses spoken and sign language in daily communication.

Student D, a 17-year-old female, has severe hearing loss. The student got a 90 for science and a 92 for Development of Sound and Rhythm Perception Communication (PKPBI). The student is aware of the presence or absence of sound during the sound detection stage, but with a loud voice. In everyday communication, the student uses sign language, as well as spoken and written language.

Student E is a 19-year-old male who has a moderate degree of hearing loss. The student got 86 for science and 88 for PKPBI. The student is aware of the presence or absence of loud sounds. The student uses sign language in daily communication. The student does not use oral or spoken language.

### 3.2. Experimental results

The frequency of the sound source wave heard by the listener can change due to changes in the position of the sound source or the position of the listener. This state is called the Doppler effect (see Fig. 1) [15, 21].

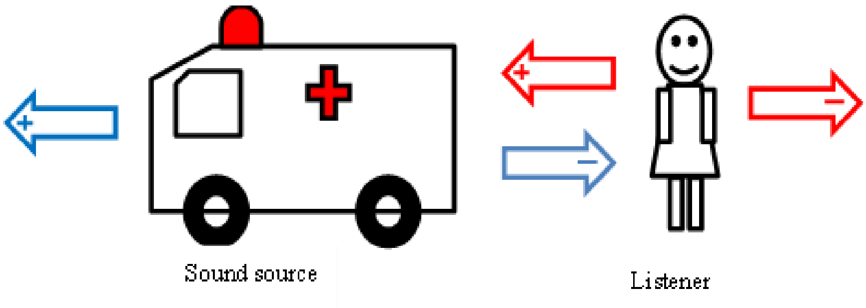


**Fig. 1. Use of positive and negative signs for sound sources and listeners.**

The Doppler effect can be formulated by Eq. (1):

$$f_p = \frac{v \pm v_p}{v \pm v_s} \times f_s \qquad (1)$$

Where $f_p$ is the frequency heard by the listener (Hz), $f_s$ is the frequency emitted by the sound source (Hz), $v$ is the speed of sound in air (m/s), $v_p$ is the speed of the listener (if moving - (m/s)), and $v_s$ is the speed of the sound source (if it moves - (m/s)).

Pay attention to the formula above, the ± sign above can mean + (positive) or - (negative) depending on the condition of the listener and also the source of the sound (see Fig. 2). The following are the rules regarding the use of the plus and minus signs:

(i) $v_p$ value + (positive) if the listener is approaching the sound source, and value - (negative) if away from the sound source

(ii) $v_s$ value + (positive) if the sound source is away from the listener and is worth – (negative) if it is approaching the listener.

### 3.3. Teaching process

Teaching the concept of the Doppler effect to students with DHH requires appropriate strategies and media so that the material can be taught to students and understood by students. The strategy chosen is through a learning video (see Fig. 2) which is modified according to the needs of students. Learning videos include images that correspond to the material as well as sentences that explain the material. The sentences used are chosen based on the stage of language development of the students. The sentence has been simplified. Thus, students can better understand its meaning. Steps in the process of teaching the concept of the Doppler effect to deaf students were:

(i) Prepare a learning video

(ii) Students are asked to watch a learning video about the Doppler effect that has been prepared

(iii) Students are allowed to ask the teacher

(iv) The teacher explains the material in the learning video again (if there are students who do not understand)

(v) Pay attention to students' expressions when they see the learning video.


**Fig. 2. Cover of a learning video about knowing the doppler effect.**

The concept of the material presented to students is: "If we (listeners) are silent and hear a sound from a silent source, the sound we hear will have the same frequency as the source." The Doppler effect, on the other hand, occurs when the sound source moves toward the listener or vice versa. As an example, if we hear a siren car approaching us, the siren sound will intensify (pitch or sound frequency is getting higher). The siren sound will then become smaller as the car passes us and moves further away (lower pitch). This is the Doppler effect or the change in sound frequency caused by a moving sound source (see Fig. 3).

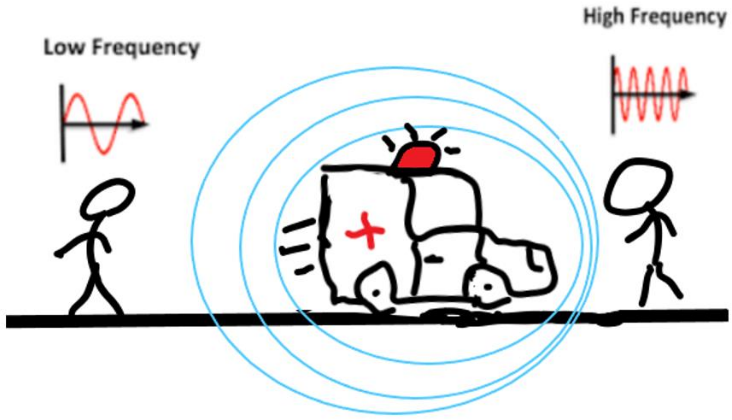


**Fig. 3. The doppler effect on frequency or wavelength.**

### 3.4. Sound reflection taught to students

Table 1 compares students' understanding of the Doppler effect before and after viewing a learning video about the modified Doppler effect. Some students got 0 before the activity, but after watching the learning video, their understanding of the Doppler effect improved.

Before the activity, student A was unaware that a stationary object could not produce sound. The student was also unaware that sound spread in all directions. The student also failed to recognize that as the source of the sound moves away, the sound becomes less audible. The student was unaware that the Doppler effect was caused by changes in the listener's position. The student was also unaware of the discovery of the Doppler effect knowledge or expertise. The student understood all of the material after the activity. The student received one point for each statement.

Student B's scores did not change before and after the activity. Student B received 8 points out of the possible 10 points. Following the activity, Student C experienced an increase in understanding. It has been established that student C received two additional scores, namely 8 and 10. Student C had a score of 7 before the activity, but it increased to 9 afterward.

Students D and E did not have an increase in their scores following the activity, but there was a shift in the order of the points obtained. Before the activity, Student D received a score of 1 on statements 1, 2, 3, 4, 5, 6, 7, and 10. However, following the activity, statements 1, 2, 3, 4, 5, 8, 9, and 10 received a score of 1. Before the activity, student E had a score of 1 on statements 3, 7, and 10. However, following the activity, the student received a score of 1 on statements 5, 7, and 10.

**Table 1. Comparison of subject.**

| Statement | Student | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | | B | | C | | D | | E | |
| | W0 | W | W0 | W | W0 | W | W0 | W | W0 | W |
| 1. Sound is produced by a stationary object | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 2. Sound waves propagate through a medium | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 3. The higher the frequency of the sound, the closer the sound waves are | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 4. The sound spreads only toward the front | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 5. As the source of the sound approaches, the sound gets louder | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 6. As the source of the sound moves away, the sound gets louder | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 7. The Doppler effect occurs due to changes in the position of the sound source | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| 8. The Doppler effect is caused by a change in the position of the listener | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 9. Doppler effect was discovered by biologists | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 10. Doppler effect was discovered by Christian Andreas | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |

## 3.5. Student’s Doppler effect awareness

Table 2 displays the findings of observations of students' attitudes or expressions when presented with material and an explanation of the Doppler effect.

**Table 2. Student’s Doppler effect awareness.**

| Things to observe | Subject | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| Students pay attention when the material is delivered | 2 | 2 | 2 | 2 | 2 |
| Students demonstrate an understanding that as the source of the sound approaches, the sound gets louder and louder | 2 | 2 | 2 | 2 | 2 |
| Students demonstrate an understanding that as the sound source moves away, the sound becomes less and less audible | 2 | 2 | 2 | 2 | 2 |

## 4. Conclusion

Based on the findings of this study, it is possible to teach the material about the Doppler effect to DHH students by tailoring it to their specific needs. The content in the learning videos and the teacher's ability to explain the material influence DHH students' success in mastering the material. The ability to read and comprehend learning videos is critical to this achievement. Although DHH students cannot hear optimally, they understand that the frequency of sound waves heard by listeners can change as the position of the sound source or the listener changes. According to the student scores, two students did not show an increase in understanding the material because they did not understand the material presented in the learning video, which only contained pictures of the material. Because the two students use sign language as their primary mode of communication, using sign language in DHH learning videos is highly recommended. Unlike the other three students, they improved their understanding despite the absence of sign language in the learning videos.

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