

# The persistence of students' alternative conceptions in wave propagation

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*Abstract: This research investigates the persistence of students' conceptions between two groups of students, on the topic of wave propagation. The first group consists of 55 grade 12 students who had already learned mechanical waves by traditional teaching in school. The other consists of 83 grade 10 students who had never learned this topic. These two groups are at the same school. The research instrument used is a series of open-ended questions dealing with basic concepts of wave propagation. The results show that students' alternative conceptions between these two groups are nearly identical. The most fundamental common alternative conceptions are:*

- a. sound waves of higher frequency moves faster than those of lower frequency;*
- b. sound waves of higher volume move faster because they have higher energy;*
- c. waves with greater amplitudes have more energy, hence they move faster; and*
- d. the speed of a wave on a string can be changed by changing the movement of the instructor's hand.*

*These research findings will be a guide for the development of a conceptual diagnostic test on the topic of mechanical waves.*

## Introduction

The study of mechanical wave motion is important for application to higher study such as quantum mechanics, waves and optics, other fields using the concepts of waves to understand some phenomena in their study. Some research on mechanical waves reveals that students have many alternative conceptions. They have difficulties with separating the direction of motion of the wave from the motion of the medium. They also show misunderstanding about what a wave is. In our study, we present findings about student alternative conceptions in wave propagation for Thai high school students.

## Methodology

To study this, we used the wave diagnostic test (WDT) as the instrument to probe students' conceptions. This survey was developed by Micheal C. Wittmann at the University of Maryland. It is composed of ten items, separated into two parts. The first part consists of eight free response questions (FR). The second consists of two-multiple choice multiple response questions. These two questions are the same as in the first part, testing students for the second time in multiple-choice, multiple-response (MCMR) format. The test was translated into Thai before using it. There are three main concepts in the test: propagation, reflection and superposition of waves. In this paper we describe the findings in only one concept: propagation. The sample of the study was 83 Grade 10 high school students who had never learned the wave topic and 55 Grade 12 high school students who had already learned the wave topic.

### Sample question 1

Michael and Laura are standing 100 m apart and yell 'Yo!' at each other at exactly the same instant. Michael yells louder than Laura, and the pitch (frequency) of his voice is lower.

Will Laura hear Michael first, Michael hear Laura first, or will they hear each other at the same time? Explain how you arrived at your answer.

### Sample question 2

A person holds a long, taut string and quickly moves her hand up and down, creating a pulse which



moves toward the wall to which the string is attached. The pulse reaches the wall in a time  $t$ . How could the person decrease the amount of time it takes for the pulse to reach the wall? Explain.

## Results and discussion

The results show that both groups of the students have nearly identical alternative conceptions. Although one group had already learned this topic, they still have the same alternative conceptions as the group who had never learned this topic. The common alternative conception in this topic are: a) sound waves of higher frequency move faster than those of lower frequency, b) sound waves of higher volume move faster because they have higher energy, c) waves with higher amplitude have more energy, hence they move faster, d) the speed of waves on a string can be changed by changing the hand movement.

Students' responses to some conceptual questions in the topic of wave propagation are shown in Table 1.

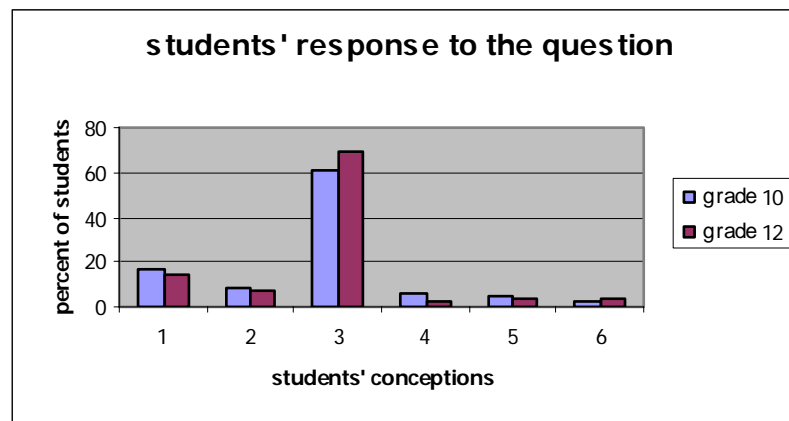
**Table 1.** Sample Question 1

### Sample Question 1

Student responses to this question gave six different statements to justify their answers:

1. The speed of a sound wave depends only on the properties of the medium (the correct answer).
2. The speed of a sound wave depends on both frequency and volume.
3. The speed of a sound wave depends on its frequency.
4. The speed of a sound wave depends on its volume
5. Other
6. left blank

The fractions of students offering each of these statements are shown in Figure 1.



**Figure 1.** Students' conceptions

The results show that both groups of the sample have almost identical alternative conceptions. The most common alternative conception for both groups is that speed of a sound wave depends on its frequency, and this belief is obviously not changed by instruction.

### Sample Question 2

Student responses to this question gave five different statements to justify their answers.

1. The speed of a wave on the string can only be changed by changing the properties of the string.
2. The speed of a wave on the string can be changed by shaking the end faster or slower, thus changing the frequency/wavelength.

3. The speed of a wave on the string can be changed by shaking the end loss vigorously, to make the wave smaller.
4. The speed of a wave on the string can be changed by applying more/less force to the string.
5. Other/blank.

The fractions of students offering each of these statements are shown in Figure 2.

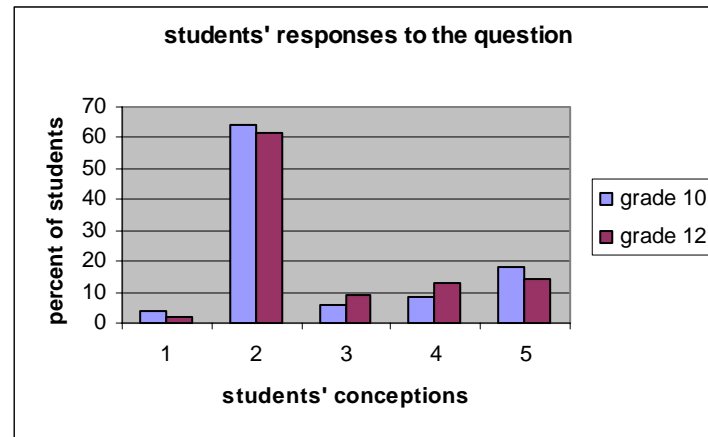


Figure 2. Students' conceptions on speed of wave on string

Again, the results from this question show that both groups of students have almost identical alternative conceptions. The most common alternative conceptions on this topic is that they believe that the speed of wave on string depends on hand movement to make more frequency and amplitude. And again, this belief is not changed by instruction.

## Conclusion

We describe the results of students' alternative conceptions on the topic of wave propagation. We used the survey called the Wave Diagnostic Test (WDT) to probe students' conceptions with two groups of the students. We have identified four specific misconceptions which students who have never studied the subject will choose from our survey. The interesting point is that students who are two years older, and have studied the subject, still make the same choices. Traditional schooling in this area apparently does not shift deeply held misconception.

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